The Institute of Physics

BULLETIN

JANUARY 1958 · VOL. 9 · No. 1

CONTENTS

NOTICES TO MEMBERS
Page 1

KEPLER AND THE LAW OF REFRACTION
R. A. HOUSTON
Page 3

FOOD SUPPLY IN THE NUCLEAR AGE
PROFESSOR HUGH NICOL
Page 7

THE DESIGN OF PHYSICS RESEARCH LABORATORIES
J. S. FORREST
Page 13

REVIEWS OF BOOKS
Page 16

FORTHCOMING INSTITUTE MEETINGS
Page 18

THE REGISTER
Page 20

THE INSTITUTE'S JOURNALS
Page 22

The Bulletin is published by The Institute of Physics for circulation to its members.

Notices to Members

Annual Dinner

Details of the first annual dinner to be held on March 26 at the Savoy Hotel, London, will be circulated to members shortly. The principal speakers will be the Lord President of the Council, Rt. Hon. Viscount Hailsham, Q.C., and Sir George Barnes, Principal of the University College of North Staffordshire.

Payment of Annual Fees

Members are again asked to co-operate in reducing the cost and labour of collecting fees by using the form printed on page iv. This form is *not* intended for those members who pay fees by bankers' order.

The Institute's 1958 Budget

At its meeting on December 3 the Board approved the budget for 1958 submitted by the Treasurer on behalf of the Finance and General Purposes Committee. The estimates of income and expenditure are slightly less than those for 1957 because of the change of policy over the publication of books, referred to in the last issue of the *Bulletin*. The budget estimates total income in 1958 to be £60,300 (compared with £61,250 for 1957). Of this sum, £43,700 is expected to come from the sale of publications, now almost wholly journals, and the net advertising revenue from the journals. The corresponding total for 1957 is estimated to be £44,500. Members' subscriptions are conservatively estimated to total £15,000 (£14,600 in 1957).

The two main items of expenditure are £19,600 for production and distribution of publications (excluding staff salaries and overheads) and £19,800 on salaries, wages, insurance and superannuation. Nearly one half of the latter figure is attributable to the production and distribution of publications. The cost of the house, including cleaning and care-taking, is estimated at £6,100. Cash grants to Branches and Groups, exclusive of the cost of work done for Branches and Groups and borne on other accounts is £2,700.

A total of £1,350 has been allowed for writing-off the cost of furniture, fittings and alterations and £985 is allowed for the premium on the leasehold redemption policy from which the Institute will receive £40,000 on expiry of the lease of the House.

Bulletin : Display in libraries of schools, colleges and universities

Members who teach in universities, recognized technical colleges and schools are reminded that they may obtain extra copies of the *Bulletin*, free of charge, for display in the libraries of these institutions. Requests should be addressed to the Deputy Secretary. An additional copy for this purpose will be sent each month ; copies are available only through members.

Non-Destructive Testing Group Meeting ; Correction

In the December *Bulletin* the venue for the meeting of the Non-Destructive Testing Group to be held on January 17 was given as the Institute's House. In fact, it will be held at the Criterion Restaurant, Piccadilly Circus. After Dinner (6.30 p.m. for 7 p.m.) to which ladies are invited, Professor C. B. Allsopp (*Fellow*) will speak on " Some Applications of Physics in the Investigation of Crime." Dress is informal. Tickets must be obtained before the meeting ; they are 20s. single and 35s. double, and enquiries should be sent to Mr. L. Lawrence at the Institute's House.

Binding of the Bulletin

Those members who wish to have their copies of the 1957 volume of the *Bulletin* bound by the printers should send the twelve issues direct to F. J. Milner and Sons Ltd., Commerce Road, Brentford, Middlesex, enclosing a sheet with the name and address of the sender and a remittance for sixteen shillings made payable to the firm. A title page and contents list will be supplied by the printer.

Radiofrequency Spectroscopy

The informal Radiofrequency Spectroscopy Group will hold a discussion on " High Resolution Nuclear Magnetic Resonance " in Oxford from 5 p.m. on April 21 until 7 p.m. on April 22. Limited accommodation will be available in College for those who wish it. Reservation forms for this may be obtained from Dr. R. Richards, Lincoln College, Oxford.

It is hoped that there will be contributions on " The Theory of High Resolution Spectra, its application to organic and inorganic chemistry, and on the design of Spectrometers."

Another Meeting will be held on September 22-23, 1958, on " Magnetic Resonance in the Solid State " at Newcastle, organized by Dr. Schneider. Those wishing to have further information on this meeting and future arrangements should write to Dr. D. J. E. Ingram, Honorary Secretary, Radiofrequency Spectroscopy Group, The University, Southampton.

Bristol Vacation School on Dislocations in Metals and Inorganic Crystals

A vacation school on Observations of Dislocations in Metals and Inorganic Crystals will be held in the H. H. Wills Physical Laboratory, the University of Bristol, from March 24 until mid-day on Saturday, March 29. Lectures will be given by Professor F. C. Frank, Dr. J. W. Mitchell, Dr. J. F. Nye, Dr. N. Thompson and other research workers from this country.

The course is intended mainly for research students at Universities and for members of the staffs of Government and Industrial Laboratories.

The number attending is limited to 120 and application must be made by February 1 ; accommodation is available in Wills Hall. The fee for attendance, exclusive of accommodation is £10 10s. 0d. Forms of application may be obtained from Dr. N. Thompson (*Fellow*), H. H. Wills Physical Laboratory, Royal Fort, Bristol 8.

Vol. 9, January, 1958

Kepler and the Law of Refraction

By R. A. HOUSTOUN, M.A., D.Sc., F.Inst.P.

(*University of Glasgow*)

EVERY student of optics knows that the angles of incidence and refraction of a ray, i and r, are connected by the relation $\mu = \sin i / \sin r$, where μ is a constant known as the index of refraction. The astonomer Kepler tried to determine this relation on the basis of the data available in his day and found instead the relation

$$i - r = ki \sec r$$

Whewell in his *History of the Inductive Sciences* says it is strange that he should have obtained this formula, when the correct law is so simple, and in a review in *Nature*[1] Prof. H. C. Plummer also wonders how he got it, for it is both awkward for calculation and violates the principle of the reversibility of the ray. There is an interesting reason for Kepler's result which has escaped his commentators. I made a brief reference to it eighteen years ago[2] and I propose to go into the matter in more detail here.

The standard work on optics in Kepler's day was Vitellio's *Perspective*. This was printed several times in the sixteenth century and is easily available ; Glasgow University Library has, for example, two copies. Table 1 is taken from p. 257 of the 1551 edition which was printed at Nuremberg. The first column gives angles of incidence, the second, fifth and eighth columns the corresponding angles of refraction for an air-water, air-glass and water-glass surface. Claudius Ptolemy, the astronomer who flourished at Alexandria at the end of the first century A.D., gives almost identical tables in the fifth book of his *Opticorum Sermones*. There are manuscript copies of this work, translated from Arabic into Latin, in the Royal Library at Paris and in the Bodleian Library at Oxford. The entries in the third, fourth, sixth and seventh columns give the values in these MSS. where they differ from Vitellio's values. They agree with Vitellio for the case of water to glass.

The question arises as to whether Vitellio made observations of his own or merely copied out Ptolemy's results. On this point he is quite definite. "*Acceptis instrumentaliter, prout potuimus propinquius, angulis omnium refractionum . . . invenimus quod semper iidem sunt anguli refractionum : . . . secundum hoc fecimus has tabulas.*" Whewell translates this as "Having measured by means of instruments, as exactly as we could, the whole range of the angles of refraction, we found that the refraction is always the same for the same angle ; and hence we have constructed these Tables."

Professor Rigaud says with reference to Ptolemy's determination[3] :

"Ptolemy begins by explaining the experiment with the piece of money which, when concealed behind the side of a vessel, becomes visible by filling it with water. The refraction of the visual ray in penetrating the water makes us see the piece of money out of its place, and in the prolongation of the primitive direction of the ray emitted by the eye. In order to measure this refraction at different angles, Ptolemy employs a circle divided into 360°, the inferior half of which is plunged in the water, so that the refracting surface covers one of the diameters of the circle. The centre of the

Table 1

	Air to Water						*Air to Glass*						*Water to Glass*	
	Vitellio		*Paris*		*Oxford*		*Vitellio*		*Paris*		*Oxford*			
10° ...	7°	45′	8°	0′	8°	0′	7°	0′					9°	30′
20° ...	15°	30′					13°	30′					18°	30′
30° ...	22°	30′					19°	30′	20°	30′	18°	30′	27°	0′
40° ...	29°	0′	28°	0′	28°	0′	25°	0′					35°	0′
50° ...	35°	0′					30°	0′					42°	30′
60° ...	40°	30′					34°	30′					49°	30′
70° ...	45°	30′	45°	0′			38°	30′					56°	0′
80° ...	50°	0′					42°	0′					62°	0′

[1] *Nature*, **144**, 306, 1939. [2] *Nature*, **144**, 441, 1939.

[3] Article on Optics, Enc. Brit., 8th edition.

circle is marked out by a small coloured body, and a second similar body is fitted to one of the quadrants out of the water, and at a given distance from the vertical diameter ; a third coloured body slides on the lower quadrant, which is immersed in the water. This last body is then pushed with a rod till the eye placed on the body in the air sees all the three in a straight line. The two distances of the second and third body from the vertical diameter are thus measured on the graduated circle. . . .

" In order to measure the angles of refraction from air into glass, Ptolemy adopted the ingenious idea of procuring a semi-cylinder of pure glass, and adjusting the diameter of it so as to coincide with the horizontal diameter of the graduated circle already described. By performing the very same experiment which he made with water, he found that there was no refraction at a perpendicular incidence ; but that for every other position the angle in the air was always greater than the angle in the glass, and the refraction greater than in water . . . When the three bodies were placed in appearance in the same straight line they always remained there, whether the eye was placed above the glass or below it. . . .

" When the semi-cylinder of glass was placed on the surface of water, Ptolemy observed that the refractions from water into glass were less than any he had observed, because the difference of density between water and glass was less than between water and air."

Ptolemy's observations are of interest as being the earliest physical measurements on record.

Kepler investigates the law of refraction in his " *Ad Vitellionem Paralipomena* " or *Supplement to Vitellio*, a 449 page treatise published in Frankfurt in 1604, four years before Lippershey made the first telescope. Thirty-nine of these pages, or about 11,000 words, are devoted to the law of refraction. It was Kepler's habit in describing the solution of a problem to give a very full account of all the unsuccessful attempts he made before arriving at the right result. Indeed he says in one of his books, " if Christopher Columbus, if Magellan, if the Portuguese, when they narrate their wanderings, are not only excused, but if we do not wish these passages omitted, and should lose much pleasure if they were, let no one blame me for doing the same." Kepler's investigation of the law of refraction is in keeping with this characteristic and may aptly be described as a chronicle of " wanderings."

He approaches the subject from astronomical refraction, the apparent displacement of the celestial bodies by the passage of their rays through the earth's atmosphere. First there is a refutation of previous work on the subject (nine pages) ; then a " preparation for the correct measure of refraction " (four pages). This opens with the sentences " Hitherto I have investigated at random and trusted to luck. But a new prospect opened out when I adopted a reliable procedure." There is then a disquisition on the conic sections (four pages) and next a section entitled " What kind of quantity measures refraction ? " Here we come upon something more definite.

According to Vitellio when the angle of incidence at an air-water surface is 80° the angle of refraction is 50°. In Fig. 1 $F\hat{B}A$ is 80° and $F\hat{A}B$ 50°. Kepler assumed that F is a point on a

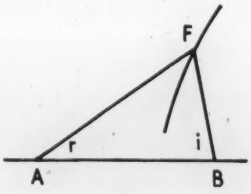

Figure 1

hyperbola and that A and B are its foci. The hyperbola is then completely determined. Kepler then moves the point F along the hyperbola and tries whether the angles FBA and FAB continue to satisfy Vitellio's tables. He finds they do not and applies the same procedure to the ellipse, Fig. 2, with no better success. He next considers the

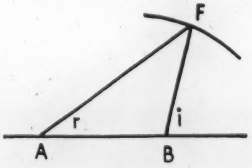

Figure 2

application of the parabola to the problem and comes up against the obvious difficulty that there is only one focus. This involves changes in the plan and inspires lengthy calculations that lead nowhere. But in the midst of them occurs the sentence " *Deum immortalem quantum mihi temporis et operae perdidit Gebri fiducia*," " Almighty God, how much time and trouble have I lost through my trust in Geber." The editor of the collected

edition of Kepler's works, Dr. Frisch, is not clear as to the exact meaning of this. Geber was the most celebrated chemist of medieval times and has no apparent connection with the matter. Possibly in this connection he personifies algebra.

The next section opens with the sentences : "Truly, dear reader, I have kept you long enough in suspense while I was striving to collect the relations of the different refractions into one section, but I must confess that the root of the matter is not there. For what have the refractions which we have shown to exist, for the first time, at the plane surface of transparent substances, to do with conic sections ? Therefore with God's good help we will try hard to get at the cause." On p. 111 there is a diagram of which Fig. 3 is a modified form. It represents a beam of parallel

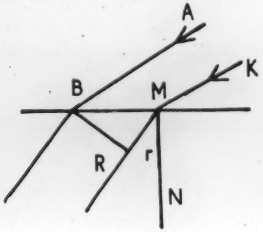

Figure 3

rays incident on a refracting surface, *AB* and *KM* being the limiting rays of the beam. *RMN* is the angle of refraction, *r*. The refraction, Kepler thinks, must be proportional to the density encountered by the beam. This he takes as proportional to $BM = BR \sec r$.

After three more pages we arrive suddenly at the problem of finding the angle of refraction for any angle of incidence, given its value for one angle. Kepler is interested in $i - r$, not r, and he assumes that this is approximately proportional to i. This was a general assumption in medieval times. So the law is approximately $i - r = kr$. Influenced by Fig. 3 he then takes the deviation from proportionality as given by sec r. Thus the complete law is given by

$$i - r = ki \sec r$$

The result is not stated explicitly, but it is implicit in his procedure. On applying it to Vitellio's air-water data he obtains the figures in the third column of Table 2. They give the excess of r calculated by his formula over Vitellio's observations. The fourth column gives the excess of r over Vitellio's observations, when it is calculated by the modern formula for $n = 1{\cdot}333$. It is obvious that Kepler's formula agrees much better with the observations than the modern one does, owing to the last experimental value being very far out.

Table 2

	r Vitellio's observations	*Excess of r calculated by Kepler's formula over Vitellio's observations*	*Excess of r calculated by modern formula over Vitellio's observations*
10°	7° 45′	−11′	−16′
20°	15° 30′	−29′	−39′
30°	22° 30′	−19′	−28′
40°	29° 0′	+2′	−10′
50°	35° 0′	+14′	+4′
60°	40° 30′	+22′	+1′
70°	45° 30′	+19′	−41′
80°	50° 0′	+0′	−2° 22′

This is shown by the middle curve of Fig. 4. Abscissae are angles of incidence, ordinates

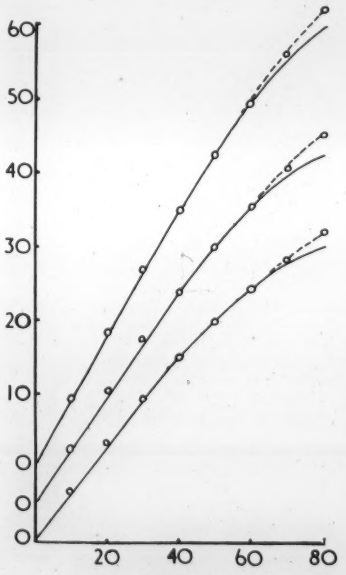

Figure 4

Abscissæ are angles of incidence, ordinates angles of refraction. The middle curve is air to water, the lower is air to glass and the upper water to glass.

angles of refraction. The circles are Vitellio's observations. The full line is calculated by the modern formula to fit the observations. The broken line is calculated by Kepler's formula ; where it is not shown, it coincides with the full line. Kepler's formula, like the modern one, is a one-constant formula.

Kepler did not apply his formula to Vitellio's air-glass and water-glass data. I have done so and give the result in the diagram. The lower curve is for air-glass and the upper one for water-glass. The full line is calculated by the modern formula for refractive indices of 1·532 and 1·139 respectively and the broken line by Kepler's law for $k = \cdot 3530$ and $\cdot 1056$. Thus Kepler's formula fits the first six points as well as the modern one, is definitely better at the seventh point and much better at the last one.

Ptolemy's last values are very bad ones. Vitellio reproduces them without alteration. We have thus identity of error and conclude that Vitellio made no independent measurements. This conclusion is strengthened by an extraordinary table (Table 3) which Vitellio gives for

Table 3

Incidence	*Water to Air*	*Glass to Air*	*Glass to Water*
10°	12° 5′	13° 0′	10° 30′
20°	24° 30′	26° 30′	21° 30′
30°	37° 30′	40° 0′	33° 0′
40°	51° 0′	55° 30′	45° 0′
50°	65° 0′	70° 30′	57° 30′
60°	79° 30′	85° 0′	70° 30′
70°	94° 30′	101° 30′	84° 0′
80°	110° 0′	118° 0′	98° 0′

refraction at a water-air, a glass-air and a glass-water surface. The first column gives the angle of incidence in the denser medium, the other three columns the angle of refraction in the less dense medium. It is greater than the angle of incidence, as we would expect, but after reaching 90°, which it does for angles of about 67°, 63° and 74° respectively, it carries on in the other medium. Any experiments Vitellio made on refraction must have been of a very superficial nature. Ptolemy missed total reflection, so far as we can gather from Delambre's analysis of his work.[4] Kepler makes no reference to it in the *Paralipomena*, but he describes it quite clearly in the *Dioptric* and gives the correct value of the limiting angle for glass. The *Dioptric* was published in 1611, seven years after the *Paralipomena* and two years after Galileo's discovery of Jupiter's moons. It is a much clearer, more satisfactory book than the latter.

Vitellio constructs these tables by assuming that, for the same surface of separation, the deviation is always the same for the same angle of incidence. Thus for air-water, when the angle of incidence is 50°, the angle of refraction is 35°, the difference being 15°, and for water-air, when the angle of incidence is 50°, the angle of refraction must be $50 + 15 = 65°$. Except for three trifling differences the angles in the second table all obey this simple rule.

Kepler started the *Paralipomena* early in 1603 and completed it the same year, so it must have been forced labour, and most of the pages dealing with refraction have little value as physics and should have been re-written or suppressed. But they are interesting from the standpoint of the psychology of discovery. Newton said that a problem was solved by devoting intense thought to it and Poincaré says somewhere that after the period of intense effort, when the problem has been given up, the solution is thrown up by the subconscious. During the period of intense effort the mind races and repeats itself and is not very logical. So Kepler's work here is not very intelligent, but it shows an intense, blind determination and the solution comes unexpectedly. He depicts the process of discovery. Physicists nowadays when they reach a new standpoint usually suppress or rationalize the wild ideas they had on the way up. Sometimes they even forget about them.

Ptolemy's observations on refraction are such as a twelve year old schoolboy could make nowadays in an hour. They satisfied Europe for 15 centuries. They are accurate to about 30′ and Tycho Brahe observed to 1′. Yet Kepler never thought of repeating them.

[4] Delambre, Histoire de l'astronomie ancienne, Paris, 1817, Vol. II, p. 411.

Vol. 9, January, 1958

Food Supply in the Nuclear Age*

By Professor HUGH NICOL, Ph.D.

(*West of Scotland Agricultural College*)

I AM NOT competent to talk about training of physicists specifically ; accordingly, I propose to talk about the training of everybody—about some realities of the food situation.

Some physicists who talk about energy are unmindful about what is to go into the other pan. We hear of great hopes from hydrogen fusion ; so that when fusion becomes practicable, energy will be unlimited because there is illimitable water in the sea. Yet we can't live on water ; nor can we live on any kind of energy except one.

That indispensable energy is the old-fashioned sort which comes from having enough of the right sort of things to put between one's teeth : now, to-morrow, next year, next century, for the next thousand years and so on : and, roughly, three times a day. I like my food and wine. But some scientists seem to believe that primeval necessities are no concern of theirs. Either they have risen above such things, and have progressed into realms far beyond the earth-bound ones I inhabit, so as to have become superior to the traditional needs to eat and to prepare for next year's harvest ; or else they just take food, and its indefinite continuance, for granted : which is to say, without thought. However, I shall proceed on the hypothesis that all those present have had supper.

Let us look at man's present situation, with special reference to the technically advanced peoples such as ourselves. Study of the relationships of plants and animals with each other and with their surroundings is called ecology. There are thousands of ecologists in the world. They include wild-life conservators, fishery scientists, and students of bird behaviour. Some of them have understood that man's operations ought to be included in their ambit, since man is not only an animal but has lately exerted a dominating influence on his surroundings ; however, few ecologists have a training in the exact sciences. A consequence is that their outlook has been confined to features which are not only of the surface of the earth but are in theory perpetually renewable, such as forests, streams, and the sea. What is deep in the earth is, apparently, not part of " nature."

A soil chemist like myself, engaged in what is called " agricultural chemistry "—or, as I prefer to call it, chemical ecology—is trained to look beneath the surface, for that is where the soil is. It is perhaps because of the limitations of their training that the recognized ecologists, such as those taking part in current B.B.C. talks on the balance of nature, have overlooked the fact that man is seriously imperilling himself through risking his food-supply by biting into reserves laid down under the earth.

During one lifetime, two chemical factors of living have become inescapable. One is that everyone is henceforth subject to possibly dangerous radiation emitted by strontium released by " atomic " explosions. Being a by-product of nuclear research, this has had a good deal of notice ; it would hardly be too much to say that it is the only biological problem of the future that is receiving serious attention at the highest levels. The menace of the other chemical factor is hardly older, is different, possibly more grave, but less immediate.

This second—chronologically first—chemical factor comes from the fact that change in man's circumstances and in his relations with nature took shape about sixty years ago, when, for the first time in history, mankind ceased to rely on sun, sea, soil and other surface features of the earth to produce all his food. Instead, a proportion of us began to make use of fuels and other fossil reserves to produce part of our food (as well as continuing to use fuel for producing energy external to our bodies).

No professional historian has noticed this tremendous historical dichotomy, and its social significance has gone unperceived. It has an obvious scientific basis, so it is tempting to link up this talk with " Science in government."

Physics is well off for governmental support and encouragement. Nuclear problems are recognized by governments as having a scientific and technical nexus, so that scientists and technologists are consulted in high places. There is no public understanding that there is a special scientific nexus to the food problem ; no guidance on the point is offered, for example, by F.A.O.

* A lecture given at the Scottish Conference on Training in Physics held in Glasgow by the Institute's Scottish Branch and Education Group, April 12-13, 1957.

The fiasco of the ground-nut scheme was conceived nearer home. It could have been avoided by making a preliminary soil survey costing a few thousand pounds, but scientific advice was not taken in advance. Can anyone imagine a similar state of affairs about the location of a power station ?

Power stations need water ; so does food-production. It has often been said that it takes as long to build a bullock as a battleship ; I might add, or a power station. It takes about as much water to produce a couple of bullocks as to float a battleship—six million gallons ; but few people concerned with fuel, external power or food-production realize that. Because of such ignorance about the links by which we get food, irrigation is one of the principal nostrums advocated to increase food-production in spectacular fashion.

The Snowy River scheme in Australia has miles of tunnels and has other engineering works primarily for generating electricity, irrigation of three million acres of food-producing land being a by-product. That sounds impressive, as if some significant addition were being made to world food. In Alberta there is another million acres irrigable. The total might feed perhaps two-and-a-half million people.

There is little understanding of the magnitude of the task to be encompassed in order to make thus an appreciable contribution to world food to say nothing of consequential requirements besides irrigation.

It has been suggested that the drainage of Los Angeles (population several millions) might be pumped up, by nuclear energy or otherwise, to irrigate the Nevada desert. This pumping would need about two million kilowatts a day.(1) The estimated amount of water is a thousand million (U.S.) gallons daily : say, equivalent to 400 bullocks a day (which wouldn't go far among three million people). On the conservative assumption that a depth of twelve inches of irrigation water per year, in addition to normal precipitation, would produce a good crop, the sewage would cover a million acres and produce crops for a few hundred thousand people.

If fresh water is insufficient, what about purifying seawater ? At the Glasgow Agricultural College we are very much interested in the energy aspects of dissolved salts in relation to growing tomatoes under glass, land reclamation in semi-arid regions, and other agricultural matters capable of fundamental treatment. I could very gladly give a talk on physico-chemical features of soils and fertilizers regarded from first principles. The applied chemistry of fertilizers has got into a very unsatisfactory state because conventions have been accepted as realities.

Much of what is fresh thinking about the physical or ionic aspects of fertilizers and the soil solution would be new not only to academic physicists unconnected with soil research but to most soil and fertilizer chemists too. For instance, it isn't for the purpose of " knocking " fertilizers that I mention that one of the two most characteristic actions of fertilizers—of any sort—is to inhibit the growth of plants. That goes hand-in-hand with the other characteristic action, which is to assist the growth of plants by supplying nutrients. The nutrient effect has had almost exclusive attention during a century of fertilizer chemistry, yet it would be an exact figure of speech to say that these two actions are handcuffed together.

We have started a fresh way of looking at Mother Earth in the light of elementary principles. For instance, it is because any dissolved substance exercises osmotic pressure that fertilizers oppose plant growth—as does the natural soil solution without fertilizers. It will be grasped, therefore, that any sort of plant growth is an equilibrium-phenomenon deserving more critical attention than it has generally had.

These questions of free energy will serve to leave a thought for you about salts in relation to plans for making use of sea water in irrigation. It would take some 50 volumes of water falling about 400 feet to yield the distributable energy needed to separate the water from one volume of sea-water.(1)

The enormous mechanical difficulties of increasing the food-supply are apparent ; but there are natural limitations as well. North American wheat—and its surplus—is produced mainly without irrigation and practically without fertilizers, from land which is naturally rich. The average yield is low and could be trebled by irrigation ; also, other crops—including much-needed protein-rich foods—could then accompany the wheat.

The yield of prairie wheat is low because rainfall restricts growth in the semi-arid regions. The soil is rich for the same reason, since it is not naturally subject to washing-out of its store of plant nutrients. A physicist will grasp instantly that the soil status is a function of balance between precipitation and evaporation. Here, as elsewhere, the rule of nature is : Nothing for nothing, and precious little for sixpence. If the prairies were to be irrigated the equilibrium would soon be disturbed, the natural richness would diminish, and there would be a colossal demand for fertilizers—as has happened on a smaller scale in a few years in Alberta.

" Fair enough," one might say ; " there is a price to be paid ; so let us contemplate construction of many more fertilizer factories to provide the food we must have." That brings in the questions about fertilizers. These, in a talismanic way (isn't science wonderful ?), are assumed to be going to solve every problem of food, especially now that " atomic " power is in sight. Most people talking about food prospects know only some of the governing factors ; many people seem to have an almost complete ignorance of the rules of the game.

Planners are often preoccupied with cereals—which cannot sustain life. We are told that if the people of Japan or Indonesia or whatever would only use so much fertilizer per acre they could produce an extra five or ten million tons of rice or wheat or what-have-you per annum. That may well be true ; but the food-value of such extra cereal—like the food-value of the millions of tons of surplus wheat we already have—would be zero. Similarly with forgetful schemes for exalting photosynthesis, in which the oversight is crippling. Cereals do contain protein, though not enough to sustain life ; but any scheme for producing sugar from the air by artificial or conventional means of reliance on photosynthesis is remote from reality, because it leaves nitrogen (as protein or otherwise) out of account.(2)

As a result of imperfect botanical teaching it is alleged that food has "always" been produced by photosynthesis ; *ergo*, to get more food, all that has to be done is to find means for increasing photosynthetic efficiency or activity per acre.

To get a true appreciation of the present and future food situation it is necessary to understand that such an allegation about photosynthesis expresses a half-truth which ignores present realities. For one thing—and perhaps that one will suffice here—photosynthesis proper operates with the elements carbon, hydrogen and oxygen only. That advocates of enlarging photosynthesis as a solution of the food problem should have forgotten, or not have known, about the role of nitrogen for sustaining plants, animals and ourselves would be incredible if the evidence of their oversights were not in their publications.(2)

The important steps in education of the public at large about food problems have not been taken by F.A.O. or other bodies at national or international levels. For example, the notion that the wheat surplus of the United States and other countries represents food has not been challenged, so the simplicist idea reigns that because wheat is undoubtedly part of food, the more wheat means that much more food. Without wanting to turn this into a discussion of dietetics, I can convince you of the falsity of that idea.

[Here Professor Nicol introduced a demonstration]

The U.S. surplus of wheat was reported some time ago to be 700 million bushels, say 42 thousand million pounds. The U.S. also had surpluses of some 90 million pounds of butter and 70 million pounds of cheese : say 10^8 pounds of each. If the wheat is converted roughly into $45 . 10^9$ pounds of bread, for each pound of bread there will be one gram each of butter and cheese.

[16 oz. of bread was shown and cut into two " slices " on which was spread a gram of butter ; a gram of cheese was also offered.

But there is a further large surplus of wheat—indicated by a second pound of bread.

There is no surplus of rice, but fancied extra production from use of fertilizers by Indonesians, etc., was shown by a bowl containing a couple of ounces of rice. Water and salt supposed *ad lib*.

To make this diet " interesting," half an ounce of sugar was added to represent an alleged surplus of sugar and/or molasses.]

This demonstrates the unsatisfying inadequacy of the supposed world surplus of " food ". The 2 lb. of bread and a bit of sugar should supply the calorific requirements of a moderately active man for one day ; for how many days would he like to exist on such a diet ?

Policy-makers know where to turn for almost any kind of non-biological information and for some kinds of biological information, say about possible radiation damage, but are untouched by the principles concerned with food, and the elegant linkages between water, soil and man.

After all, only a few hundreds of people in the United Kingdom per annum are exposed to any course in agricultural sciences, mostly to a pass degree at best, and with little opportunity to reflect about the relations of what they have learnt ; still less are their opportunities in later life for influencing thought and policy in scientific terms. As an agricultural scientist, I would have no difficulty in naming a dozen physicists prominent in national counsel ; can any of you, physicists or other, recall a single equally prominent name of an adviser on food policy concerned with a programme of the probable needs of human energy in the future ? Or are the basic needs being left to take their chance ?

We can now build a great number of factories to fix nitrogen from the air. Suppose those factories built : they still cannot assist in producing food

of any use *unless* we can also build fishing-vessels to extract a correspondingly large amount of fish-protein from the sea, or can do something to produce protein from the land to balance all that excess of carbohydrate and fat which is going to be obtained by use of all that nitrogenous fertilizer. Though the typical element of protein is nitrogen, and although that nitrogen has come from the air, Sad Fact No. 1 is that fertilizer-nitrogen cannot be safely equated with utilizable protein.

Like the other facts about plant growth and nutrition in general which I have the honour to put before you this evening, and to imply, there is nothing new about this. Each of these facts has been known for at least fifty years, and each is not only regarded as established by specialists in the relevant spheres of soil science, bacteriology, and plant, animal and human nutrition, but is borne out by practice everywhere as well as in theory.

For a constructive approach to the food problem we must turn to soil microbiology. With some exceptions of limited practical application (which I must omit, to avoid entering into details of agricultural management) it is true that, in spite of all technical advances, no large-scale agricultural method of obtaining protein in bulk is known except through the agency of soil bacteria able to fix nitrogen from the air by virtue of their special biological activities. These activities are exerted through association of those specific bacteria with leguminous plants (legumes) such as the pulse crops (peas and beans) which yield seeds directly edible by man, and the fodder legumes such as clovers, lucerne and soya which, as green plant or hay, are the mainstay of most farm livestock supplying meat, milk and cheese for balancing the cereals and the rest of the starchy component of diet.

These leguminous bacteria (as we may well call them) reduce air-nitrogen into forms which the leguminous plants build up into a richness of protein which supplies that supplement of protein which animals—including ourselves—must have to balance the other nutrients which are more easily obtained. Without apologizing for that sequence of " which's," I mention that the story of food-supply is of the House-that-Jack-built order ; and to go further into the sequences of food-production would lead us into details much beyond what is possible to display in an hour or so. So, to a sufficiently accurate first approximation, I ask you to accept the fact about the peas, beans and clovers—with their associated bacteria —being historically and always the chief source of all the vital " balancing " protein, apart from fish. There is no pleasant substitute in sight, and even the proposed unpleasant ones, such as algal protein, must require much additional fuel for their realization.

The core of the problem of food-supply is a chemical one. Like the other aspects of food, it is very simple in essence. A sufficiency of protein is the *sine qua non* of eating and remaining alive and healthy. This boils down to saying that the ultimate requirement of animals is a sufficiency of reduced nitrogen combined in suitable amino-acids of protein. That is a purely chemical statement, but reduction of air-nitrogen into acceptable and suitable foods cannot be made effective except by appeal to micro-organisms ; and that, in practice, implies growing leguminous crops in quantity.

To show that this is not just theorizing, I point out that it is precisely by growing leguminous plants—mostly for grazing—in quantity and in proportion to the increase of population that the white peoples have fed their recent increases of population. This upsurge of legumes has occurred strikingly in the " new " countries ; witness the fact that less than a century ago the immense flocks and herds of New Zealand, Australia and the United States did not exist : there were few or no fodder legumes there until the end of last century.

The increase in white and Japanese population since about 1890 may be taken as about 50% ; so it can be said that about a third of us would not now be alive if it were not for the activity of leguminous bacteria enhanced beyond its natural level in equilibrium with unaided " natural " photosynthesis, by supply of appropriate fertilizers, especially the phosphatic. Not only are the ores of these fertilizers mined ; they require ordinary fuels–i.e. reducing substance–in their preparation.

The phosphatic fertilizers containing no nitrogen are outstanding in providing our recent accessions of protein, and among the phosphatic fertilizers the chief is superphosphate, which is made by burning sulphur (or a commercial equivalent of coal, if the sulphuric acid is obtained from gypsum). So we are off on another House-that-Jack-built chase for the foundations of food. The details are unimportant here ; but it remains true that a third of our man-power and brain-power—including that of the forgetful scientists—is sustained by sulphur. Man must indeed be a little lower than the angels, since his future depends on the supply of brimstone or its equivalent ! Nevertheless, at any Fuel and Power Conference or the like, sulphur is never mentioned. It is customary to neglect human energy, as if human beings didn't really matter.

By calling on fuel to win more food than ever before, civilized man entered into an entirely new relationship with his world about sixty years ago. This is a relationship which cannot be shaken off except at unbelievable cost in suffering and conflict. Its like has never occurred before ; and it has nothing to do with aeroplanes or X-rays or radiochemistry or any other novelty which emerged at more or less the same time. Compared with this dependence on fuel for food, anything else is secondary, providing that one believes that the prime material needs of man are food, clothing, and shelter (with external physical energy occupying perhaps the fourth place).

Until the end of last century, then, man's relationship with food and the surface of the earth was what it had always been. Much—perhaps the greater part—of mankind is still living under those conditions, using little or no fossil fuel for agriculture and food-gathering.

Until our own century no novelty touching on food had had much effect on a world-scale. Where food was insufficient, the balance had generally been trimmed at the other end by reduction of population through famine, disease, tribal warfare and similar effective checks. About a hundred years ago some fertilizers were introduced into a small part of the world where also what the books call " The " Agricultural Revolution had begun to take effect. These innovations were confined to western Europe, and world consumption of fertilizer remained negligible. The essence of this, limited, First Agricultural Revolution (as I prefer to call it) was an increased growth of clover, which, by supplying more protein, enabled more animals to walk about on four legs, and on two, than previously in Europe.

The Second, and presumably final, Agricultural Revolution spread clovers and lucerne and other legumes everywhere in the world where they could grow—especially in the " new " countries, though it was paralleled in Europe—and was accompanied by the new feature of burning fuel to support those legumes and their accompanying crops. Unlike what can be done for X-rays or radio-chemistry, it is not possible always to date this major development exactly. I have taken 1890 or " sixty years ago " for convenience. It is the fuel-based new output of meat and diary products which has essentially sustained the increase in population of whites ; and in Japan fuel has been applied very largely to increase output of rice. The supplementary protein of Japanese diet comes mostly from fish ; still, beans and other legumes are important, and in Japan, as in other technically-advanced countries, food-supply has come to depend on consumption of ordinary combustibles.

Man's dependence on fuel has often been pointed out in connection with the coming of the Industrial Revolution and industrial changes since ; sometimes our dependence on fuel for machines has been linked up with " the advance of science," and not a few apologists for Progress have forecast the indefinite extension of mechanical progress thanks to the submarine telegraph or nuclear energy or whatever else is the fashion when the panegyric is uttered. That is Science with a capital S, food science being ignored because it was unformed a hundred years ago, and is widely unknown to-day ; and if Science (meaning, I suspect, nothing more than technology) looked like coming to an end because of exhaustion of coal or Chilean nitrate or petroleum or whatever, there is now atomic energy and other discoveries to confound the pessimists.

Yet the necessity of eating will remain with us. The novel, but lasting, relationship between food and fuel is critical. By laying its existence before you, I cut across the sterile beliefs of those who admit that the population is now much larger than it was, but cannot see that anything essential has changed about the production of food. If we believe these people, all we have to do to cater for an additional population δx is to set up the output of food by δy by appeal to the immemorial resources of sun and soil just as always, but necessarily on an intensified scale and with bigger use of irrigation and other technologies.

There are two fallacies in this kind of reasoning. One lies in supposing that the primitive resources of sun and soil must continue to yield all the needed food, aided, naturally enough (as this reasoning implies), by use of fertilizers and other modern aids to cultivation. The second fallacy lies in that *naturally* enough . . .

It has become so " natural " to burn fuel for various purposes, including making fertilizers and performing mechanical cultivation (which can be dismissed as only another facet of our new fuel relationship with food), that people fail to see how radical the change was when man began to produce important amounts of food by burning fuel.

It is now incorrect to contrast food and vegetable materials wholly as income in opposition to fossil reserves as capital. That boundary is no longer sharp. Unfortunately, many people — e.g. Hastings[3]—who undoubtedly know that fuel is needed for operation of aeroplanes, have their ideas about food grounded in the past. This illustrates the respective intensities of education about a necessity and an amenity. Both aeroplanes and modern supplies of food must have

fuel to keep them up ; without enough fuel both must crash.

We could do without aeroplanes ; at a cost of immense human labour we could live without tractors ; but we cannot dispense with use of fertilizers, or afford not to have the fuel for making them. This is not an instance of an interested party pleading for his special interest ; it is a statement of necessity about modern life. Many innovations which consume fuel are merely amenities, whereas a third of us would have to be removed if there were suddenly no fertilizers. The proportion of population sustained by fertilizers can be expected to increase, because any increase in our numbers can be fed only by a corresponding increase in application of fertilizers and fuel to match.

At least two questions will be asked. First, how long will fuel resources last ? That is hardly my job ; it belongs to mining engineers and people like that,[4, 5] and there is no time to review it here. The second point may arise as an objection. " But surely " (someone may say) " isn't the proportion of fuel and other minerals employed annually in food-production only a small fraction of what is dug and consumed for all purposes ? " We still use relatively little fossil material in producing and gathering food. The implication that that small proportion is therefore negligible is to be rejected. The *proportion* is small because so much fuel is being consumed for non-food purposes. Some of the heavier uses of fuel are almost frivolous. But, however the non-food uses of fossils be described, it is mostly the non-food uses which are eroding into the limited stocks of fuel and other irreplaceable reserves. So, it is the consumption of fuel for non-food purposes during the present and the next few decades which will decide how much will be left to produce food for maintaining the population of the future.

This is where considerations of nuclear and other forms of external energy can come in. For example, if instead of devoting serious thought only to the mechanical-energy gap expected to occur in a few years in spite of our burning as much coal and petroleum as possible, we devoted at least as much thought to energy as a whole, it could be clearly seen what kind of contribution nuclear energy could make to conserving fuel. The present emphasis on nuclear energy is as a merely additional source of external energy for a world which has become spendthrift of stored energy and takes no thought for the morrow except in relation to energy for machines.

The evident tendency is for modern uses of fuel to be recklessly competitive with production of food, so that we are very busy cutting away the branch on which we sit. There is a serious fuel debit against nuclear energy: for example, in the greatly increased demands on sulphur for extraction of uranium. In the United States the largest single consumer of coal for generation of electricity is the Atomic Energy Commission. Last year the Commission was estimated to have burnt, for that one purpose—coal equal to a tenth of Britain's annual output of coal.

Supply of food in this nuclear age is a scientific matter requiring the very best thought. So far it has been left to chance—since, at appropriate levels, it has received no thought realistic enough to be pertinent. It is sometimes said that scientists think more about things than about people. It is indisputable that machines have lately had much more thought than people ; so there is a reproach to be removed by education about the food situation. This is a matter in which all scientists can interest themselves.

The problem of having the food supply assured for the foreseeable future can be expressed in a simple mathematical manner analogous to that used for radioactive decay. Both with Sr^{90} and the probable future of fuel in general there is a rate of decay ; also, several unknowns enter into computation of each risk. If fuel were used only to produce food, the problem about its duration would not be serious, since the total annual consumption would remain small in relation to reserves. To repeat : the rate of decay of fuels is mainly conditioned by non-food uses of which the rate of increase is uncertain but is probably increasing. The magnitude of the future risk from Sr^{90} depends not only on the predictable decay of the isotope but also on the quantities released. If there are no more explosions, radiation risk will diminish ; otherwise, its incidence will increase.

However, the risk of food shortage from inadequacy or poor distribution of fuel and ores with which to produce food can only increase. The stock being fixed, every usage of combustibles is a subtraction, and there is nothing in sight to justify a hope that any form of contemporary external energy—not even sunlight—can generate even as much effective food as is now being produced.

The length of time during which fossil reserves may last is no longer a question only for industry and for machines ; nor can it be wholly brushed aside by appeal to nuclear energy and the like. Food is a *substance* requiring other substances for its production : it takes a chemical to make a chemical.

Unless something is done positively to leave a proper reserve of reducible substances in the earth for the specific purpose of using those and allied materials to generate food (and, notably, protein) there must be, sometime, hunger, depopulation, and all the rest. This is a matter of equilibrium between man and all his resources. Whether the worst need happen is a scientific question with determinate bases, and having an answer similarly definable.

REFERENCES

1. Hickman, K. C. D. The water conversion problem, *Indust. Engng. Chem.*, **48**, No. 4, 7A–10A, 12A, 18A, 20A (1956).
2. Nicol, Hugh. Photosynthesis and food production, *Discovery*, **17**, 146-148, 150-151 (1956).
3. Hastings, J. H. H. New products of the fermentation industry, *Chem. and Indust.*, No. 10, 274-279 esp. p. 279 (1957).
4. Ayers, Eugene, and Scarlott, C. A. *Energy sources : the wealth of the world.* McGraw-Hill, New York and London (1952).
5. Putnam, Palmer C. *Energy in the future.* Macmillan, London (1954).

(The agricultural assumptions in 4 and 5, derived from an American source, are unrealistic.)

The Design of Physics Research Laboratories*

THE lecture theatre of the Royal Institution was filled to capacity on November 27, 1957, when the London and Home Counties Branch of the Institute held a symposium on "The Design of Physics Research Laboratories."

In his introductory remarks, Dr. J. S. Forrest (Chairman) recalled that a similar discussion had been held in the same place by the London and Home Counties Branch almost exactly ten years ago. In the intervening decade, however, there has been intense activity in the building of new laboratories. Moreover the character of the physics research laboratory is changing; neat rows of standard benches equipped with standard services and apparatus are no longer suitable for dealing with many of to-day's problems which require "test rigs," pilot plants, or large machines of the heavy engineering type with the attendant erection and servicing facilities. Fig. 1, for example, shows a typical applied physics research laboratory of the conventional type which, although still useful, and in fact essential, is quite unsuitable for large equipment, such as the heat-transfer test rig shown in Fig. 2. *Space* is the primary requirement in many investigations nowadays. Services and facilities can be added

Figure 1

afterwards, but if adequate space is not available the work cannot be tackled at all.

In view of such considerations, the Branch Committee felt that the time was ripe for a further discussion to put on record the lessons learned during the last ten years, and to present the views of architects and research directors responsible for the planning of modern laboratories.

The first paper was by Professor Basil Spence, who is well known as the architect of Coventry

* A summary of the proceedings of a symposium arranged by the London and Home Counties Branch of the Institute. The full proceedings will be published early in 1958.

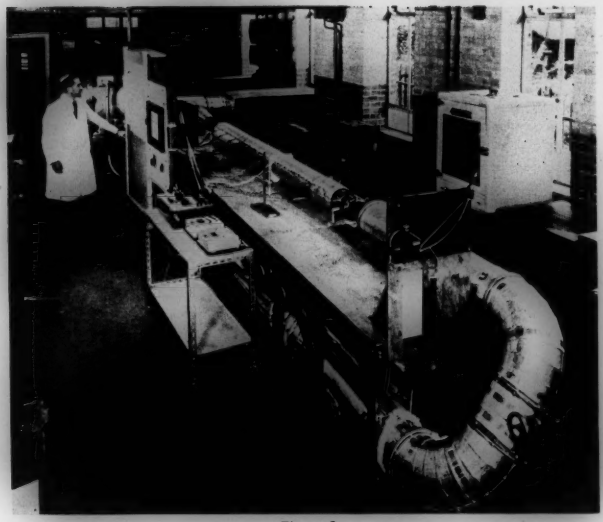

Figure 2

Cathedral. Speaking on "The Architect and Physics," he said he had been concerned with the design of university physics laboratories, such as those at Glasgow, Liverpool and Newcastle. Teaching laboratories had to cope with large numbers of students but the requirements could be defined clearly. Progress was being made in the design of lecture rooms which were now being built with less-steeply sloping tiers of seats. Research laboratories on the other hand must be extremely flexible in design as the nature of the work which might be carried out in a few years' time was unknown. In one project he had to provide for the possibility of increasing the ceiling height in the future, and a common requirement was for walls into which one could knock nails easily. Theoretical physicists frequently asked for some form of "ivory tower" in which to think great thoughts, and he had even been asked to make provision for a bed in a research laboratory!

Dr. T. Emerson showed little sympathy with such foibles in presenting his paper on "Some

Figure 3

Problems in the Planning of Industrial Research Laboratories." He emphasized the importance of good team-work between the research director, the architect and the builder. The duties and responsibilities of the various parties should be clearly defined at the outset. The requirements for accommodation and services should be co-ordinated and all instructions passed to the architect by one person only—the building supervisor. If the building supervisor were also the person who would be responsible for the future maintenance of the finished building, he could be depended on to carry out the supervision thoroughly ! The aim should be to construct an adequate building at reasonable cost with plenty of laboratory space to provide future flexibility and sufficient office accommodation. Money could be saved by omitting unnecessary frills. For instance, locks on laboratory doors were seldom used, although a subsequent speaker pointed out that they may be required for " security."

A contribution by Charles S. Haines (read by Mr. D. T. R. Dighton) discussed " Recent Trends in the Design of American Industrial Research Facilities." He said that industrial managements are now beginning to realize that the Company's future competitive position depends on the vitality of the current research programme. In the United States it is becoming common to locate the research facilities on a rural site separate from the manufacturing plant. Fig. 3 shows a good example of such a development. It is important to provide adequate space for future expansion and for " the appalling consumption of land for parking the automobile." Some companies with research organizations of approximately 100 persons are acquiring sites of over 200 acres. The design of the buildings must proceed from the inside out. To prevent early obsolescence, modular planning is essential, a module being a " three-dimensional repetitive unit of functional space." The satisfactory width of the laboratory module (usually parallel to the exterior wall) may vary from 9 to 12 feet ; the length may be from 24 to 28 feet. Office modules of 5 feet by 15 feet will provide individual and group offices of 10, 15, 20, or 25 feet by 15. Factory-finished metal partitions are preferred for sub-dividing laboratories, and they should be designed so that room arrangements may be modified without moving the mechanical and electrical services. Air-conditioning is desirable, and fume chambers may be required in physics as well as in chemistry laboratories. Safety for the scientist is of prime importance. Fire extinguishers, showers, and main switches should be located at the entrance to the laboratory. Alternative exists should be provided, and there should be a first-aid room attended by a nurse. Mr. Haines said he was not an advocate of the research palace, but the amenities must not be overlooked. " Let us have pleasantly landscaped vistas, tastefully and comfortably-furnished libraries, a lounge with chess and card-tables for the noon rest period, and even pleasant and conveniently located alcoves for the coffee break, or your equivalent—could it be tea ? "

Mr. B. C. Fleming-Williams brought us back to earth with his paper on " Services and Facilities from the User's Point of View." He emphasized the need for flexibility in the design of modern laboratories and their services. Different types of area are required in the same building, e.g. offices, libraries, conference rooms ; normal laboratories ; heavy duty areas ; workshops ; and stores. The amount and types of services differ in these areas. Full air conditioning may be required in some of the laboratories, but expense can be saved by reduced facilities in storage areas. The permanent services—water, gas and waste pipes, electric power, lighting, heating and ventilation—should be based on a modular plan. Local supplies may sometimes be preferable to a permanent central installation. For example, direct current can conveniently be supplied from individual power packs instead of from a central battery. Similarly, vacuum requirements can usually be provided by bench pumps, and supplies of various gases from local cylinders. Facilities must be available, however, for the handling and storage of gas cylinders. An adequate and easily accessible duct system should always be installed to enable any central service to be provided at any point if it is found to be desirable in the future.

Mr. J. C. Cornwell discussed " Buildings and Services from the Viewpoint of the Laboratory Maintenance Engineer." He pointed out that maintenance staffs in laboratories are more often concerned with alterations and additions to the buildings and facilities than with simply maintaining the original installation. When the laboratory is designed, provision should be made to facilitate building extensions and alterations to the services. In the choice of partitioning, sound transmission and ease of attachment of shelves are important considerations. Brick and some proprietary types of partitioning are satisfactory but steel and glass are not. Floor surfaces and their cleaning merit particular attention. Floor ducts should be designed to minimize flooding. Fire protection should receive adequate consider-

ation. Provision must be made for inflammable stores, radio-active sources, gas cylinders and bulky maintenance equipment.

Dr. R. G. Hopkinson's paper on " Research on the Design of Laboratories " described the programme of studies which are being carried out by the Nuffield Foundation Division for Architectural Studies in collaboration with the Building Research Station. The Division has made statistical studies of working space, services, storage, special rooms and building costs. Existing knowledge on heating and ventilation and on materials is applied to laboratory design. The work on laboratory lighting was carried out at the Building Research Station. From the determinations of minimum levels of natural and artificial lighting for the efficient performance of laboratory work, a design has been evolved which gives good daylighting in a single-side lit laboratory. A new form of model construction was used to assist in the appraisal of the design.

In opening the discussion, Mr. D. A. Oliver suggested that two types of laboratory accommodation were generally required—" open space " costing about £2 per sq. ft., and " better-class " laboratory accommodation costing about £4 10s. 0d. per sq. ft. The better-class accommodation should be kept free from noise, vibration and dirt ; workshops and heavy machines should be in a separate building.

Other matters discussed were the advantages of air conditioning and electric floor warming in research laboratories ; a method of providing a wide range of electricity supplies at the benches ; and a colour-light staff location system which also functioned as a fire alarm.

The authors of the papers replied briefly to some of the questions asked in the discussion, Dr. Emerson making the point that many of the design problems discussed applied to all science laboratories and not only to physics laboratories.

Finally, Professor F. A. Vick summed up the symposium and even brought out some new points which had escaped mention in the five hours' discussion. He said that the physicist must make up his own mind as to his requirements, but it was sometimes important that the outside of laboratory buildings should be in keeping with other adjacent buildings. The use of models could be a great help in planning laboratories. Workshops and equipment causing noise and vibration should be kept separate from the research laboratories and offices. The services should be very carefully designed, bearing in mind the many points raised in the discussion, and detailed plans of the services properly colour-coded should be handed over with the building. The laboratory furniture should be designed as part of the building. He agreed that it was false economy to save money on the initial cost of the laboratory—taken over a number of years the capital cost of buildings was not usually a very important item in the research laboratory budget.

Professor Vick added that the Institute would make arrangements for the publication of the proceedings of the symposium, and he asked those taking part to include detailed references to any relevant literature so that the publication would be a useful work of reference for some time to come.

J. S. Forrest.

Reviews of Books

INSTRUMENTAL ANALYSIS

By Paul Delahay

New York : Macmillan Company, 1957. Pp. 384. Price 55s. 6d.

This is a book by a chemist, written for analysts, to cover gaps in their knowledge left by the ordinary courses of physical chemistry and of chemical analysis. It is not a book for the industrial analyst so much as for the student of chemistry who is going to work in an analytical laboratory.

After a helpful chapter on the scope of physical methods of analysis, and the principles to be used in selecting a method for a particular problem, the next six chapters deal with electrical methods which apply measurement of potential, current or impedance to analytical problems. These are well covered, with the attention directed to the principles of the method and not to the details of the equipment.

The next four chapters deal with optical methods, emission and absorption spectroscopy, turbidimetry and Raman spectra, and here the treatment is more superficial ; for example flame photometry is allowed less than two pages and there is no list of the elements which can be dealt with by this method.

The next three chapters deal with X-ray absorption and diffraction as applied to analysis, then mass spectrometry, and nuclear radiation analytical methods. A short section dealing with geiger-muller counters comes under nuclear radiation methods, and the author goes so far into statistics as to mention that this affects the accuracy of analysis; he even mentions the two rather unfortunately named statistical terms, probable error and reliable error.

Throughout the book references are given to published work, nearly all between 1945 and 1955, from which the information given can be supplemented ; in the limited range where the reviewer is an expert the bibliographical references are hardly adequate.

The physicist will occasionally be surprised at how different the chemist's point of view is in this book; for example, a table of radiation at various wave-lengths, from X-ray to microwave gives for comparison energy transitions involved in kcal/mol rather than in equivalent voltages. The final chapter deals with laboratory work, and is one of the best in the book. The index is adequate, the illustrations are mostly good, but some of them have been transferred from other work without adequate explanation.

E. VAN SOMEREN.

ATOMIC RADIATION AND LIFE

By Peter Alexander

Harmondsworth : Penguin Books Ltd. Pp. xxi + 239. Price 3s. 6d.

To tackle a subject, as wide as that dealt with here, in a comparatively small book primarily designed for the man in the street, calls for considerable courage as well as literary ability. These the author certainly has and the result is a considerable, if not complete, success.

Its aim is " to put before the general reader the scientific aspects of the biological changes produced by atomic radiation." To achieve this the reader has to be given some introduction to physics, chemistry, biology and the medical sciences which are all concerned with the subject. It is not surprising, therefore, that the path followed is sometimes a difficult one and sometimes seems to get lost in a tangled undergrowth of conflicting ideas. Generally, however, the path is well chosen and clear and the reader's attention and interest are well held.

Probably the premier chapter of the book is that on the genetic effects of radiation and it is to be commended for the clarity of its exposition as well as the importance of its message. Other chapters deal with cancer cure and cancer production by radiation, the possibilities of chemical protection against the effects of radiation, the chemicals which produce the same effects as atomic radiations, and some interesting, though necessarily tentative descriptions of the mode of action of radiation on living cells.

As might be expected in a book concerning such a wide field, there is some unevenness both in the quality of the writing and the interest. The first chapter seems unnecessarily detailed in view of the small use made of some of its topics later in the book, and may well repel the general reader. The section on radiotherapy is very sketchy, giving quite unrealistic emphasis to the role of radioactive isotopes, while giving no real indication of the results that can be attained by this type of treatment.

In presenting a review of this nature the author must inevitably make some arbitrary selections of the material for inclusion. The expert may well object to some of these examples presented, for there are occasions where pontifical statements are made on the basis of experiments, the results of which have not yet received universal acceptance or are contradicted by other work. However, such cases are few and do not shake the validity of the general pictures presented.

There can be no doubt that this is a valuable book and deserves to be very widely read. The author deserves much thanks for a difficult job well done, and Penguin Books Ltd. for making work of this calibre available at such a modest price.

W. J. MEREDITH.

Forthcoming Institute Meetings

Jan. 21 Midland Branch — At the Birmingham Exchange and Engineering Centre, 7 p.m.

"The Computer and its uses"
MR. C. ROBINSON
(*English Electric Co. Ltd., Stafford*)

Jan. 22 Education Group — At the Institute's House, 6 p.m. Tea 5.30 p.m.

"Presenting Science in Physics Text Books"
MR. B. C. BROOKES
(*University College, London*)

Jan. 30 North Eastern Branch — At King's College, Newcastle-upon-Tyne, 6.15 p.m. Tea 5.30 p.m.

"Plant Biophysics"
PROFESSOR R. D. PRESTON, F.Inst.P., F.R.S.
(*University of Leeds*)

Feb. 7 South Wales Branch — In the Physics Department, University College of Swansea, 5.15 p.m.

"The Theory of the Dissolution Shapes of Crystals"
PROFESSOR F. C. FRANK, O.B.E., F.Inst.P., F.R.S.
(*University of Bristol*)

Feb. 7 Liverpool and North Wales — In the Department of Electrical Engineering, University of Liverpool, 7 p.m. Tea 6.30 p.m.

"Meteorology and Geomagnetism in the International Geophysical Year"
DR. J. M. STAGG
(*Meteorological Office*)

Feb. 10 Scottish Branch — At the University of Edinburgh, 7.15 p.m.

"Field Emission Microscopy"
DR. L. JACOB, F.Inst.P.
(*Royal College of Science and Technology, Glasgow*)

Feb. 11 Scottish Branch — At the University of Glasgow, 7.15 p.m.

"Field Emission Microscopy"
DR. L. JACOB, F.Inst.P.
(*Royal College of Science and Technology, Glasgow*)

Feb. 12 Yorkshire Branch — In the Physics Department, University of Sheffield, 5 p.m.

"Thermonuclear Power"
MR. R. S. PEASE
(*Atomic Energy Research Establishment, Harwell*)

Feb. 12 Education Group — At the Institute's House, 5.30 p.m. Tea 5 p.m.

"Discussion on the Graduateship Examination"
PROFESSOR J. G. WILSON, F.Inst.P. (*University of Leeds*)
MR. A. E. DE BARR, F.Inst.P. (*Shirley Institute, Manchester*)
PROFESSOR M. R. GAVIN, F.Inst.P. (*University College of North Wales, Bangor*)
MR. J. YARWOOD, F.Inst.P. (*The Polytechnic, Regent Street, London*)
MR. N. CLARKE, F.Inst.P. (*The Institute of Physics*)

Feb. 13 Midland Branch 3 p.m.
Visit to Physics Department, University of Nottingham,
followed by
"Current Research at British Thomson-Houston Co. Ltd."
DR. L. G. DAVIES
(Details will be circulated later)

Feb. 14 Manchester and District Branch
In the Bragg Lecture Theatre, University of Manchester, 6.30 p.m.
Branch Annual General Meeting
followed by
"The Transmission of Electrical Impulses along Nerves"
DR. R. D. KEYNES
(*The Physiological Laboratory, Cambridge*)

Feb. 14 South Western Branch At the Technical College, Gloucester, 7 p.m.
"The Physics of Thunderstorms and Lightning"
DR. B. J. MASON
(*Imperial College of Science and Technology, London*)

Feb. 14 Non-destructive Testing Group At the Institute's House, 6 p.m. Tea 5.30 p.m.
"The Analysis of wreckage in aircraft accident investigation"
MR. E. L. RIPLEY
(*Royal Aircraft Establishment, Farnborough*)

Feb. 17 Scottish Branch
In the Department of Natural Philosophy, at the University of Edinburgh, 7.15 p.m.
"The Electronic Computer in Industry"
MR. R. H. TIZARD
(*The London School of Economics and Political Science*)

Feb. 18 Electronics Group At the Institute's House, 5.30 p.m. Tea 5 p.m.
"Electronic Devices in Telephony"
DR. J. E. FLOOD
(*Siemens Edison Swan Research Laboratory, Blackheath*)

Feb. 18 Scottish Branch
In the Department of Natural Philosophy, at the University of Glasgow, 7.15 p.m.
"The Electronic Computer in Industry"
MR. R. H. TIZARD
(*The London School of Economics and Political Science*)

Feb. 19 North Eastern Branch At King's College, Newcastle-upon-Tyne, 6.15 p.m. Tea 5.30 p.m.
"Physics and Automatic Control"
MR. D. T. N. WILLIAMSON
(*Ferranti Ltd., Edinburgh*)

Feb. 19 London and Home Counties Branch At the Institute's House, 6 p.m. Tea 5.30 p.m.
Annual General Meeting
followed by
"High Polymer Properties and Structure"
DR. A. H. WILLBOURN
(*Plastics Division, Imperial Chemical Industries Ltd.*)

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE BOARD ON DECEMBER 3, 1957

An asterisk (*) indicates transfer from another grade

FELLOWS

*Corner, William Derek, B.Sc., Ph.D., Lecturer, Durham Colleges, University of Durham.

Kendrew, John Cowdery, M.A., Ph.D., Deputy Director, Medical Research Council.

*MacEwan, Douglas MacLean Clark, M.A., B.Sc., Ph.D., Principal Scientific Officer, Rothamsted Experimental Station. (Seconded to University of Granada.)

*Mackay, Alan Lindsay, M.A., B.Sc., Ph.D., Lecturer, Birkbeck College, London.

*Phillips, David Chilton, B.Sc., Ph.D., Research Fellow, The Davy-Faraday Laboratory, The Royal Institution, London.

*Posener, Desmond Walter, M.Sc., Ph.D., Senior Research Officer, C.S.I.R.O., Sydney.

*Riddiford, Leonard, M.Sc., Ph.D., Senior Staff Fellow, University of Birmingham.

Ubbelohde, Alfred Rene John Paul, M.A., D.Sc., F.R.S., Professor of Thermodynamics, Imperial College, London.

ASSOCIATES

*Ball, Clifford John, B.A., Senior Research Worker, Cavendish Laboratory, Cambridge.

Barber, Roy, B.Sc., Technical Director, Land Pyrometers Ltd., Sheffield.

*Burns, John Edwards, B.Sc., Assistant Physicist, Westminster Hospital, London.

*Butlin, John Graham, B.Sc., Technical Officer, Ferodo Ltd., Chapel-en-le-Frith, Cheshire.

*Conn, Gerald David, B.Sc., Technical Representative, Honeywell Brown Ltd., Perivale, Middlesex.

*Cornford, Samuel John, B.Sc., Senior Scientific Officer, The British Baking Industries Research Association, Chorley Wood, Herts.

Davies, James Lewis, B.Sc., Senior Physics Master, Liverpool Blue Coat School.

*Dempsey, Henry Eugene, B.Sc., Research Engineer, Canadair Ltd., Montreal.

*De Tullio, Luigi, B.Sc., Research Physicist, Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex.

*Durrant, John Kenneth Bloomfield, B.Sc., Assistant Lecturer, County Technical College, Guildford, Surrey.

Eedle, Samuel Arthur, B.Sc., Physics Master, Stoneham School, Reading, Berks.

Ellison, John McKean, B.A., Ph.D., Member of Scientific Staff, London School of Hygiene and Tropical Medicine.

*Evans, James Edward, M.Sc., Senior Scientific Officer, Nuclear Physics Division, Atomic Energy Research Establishment, Harwell, Berks.

*Green, George Dennis, B.Sc., Research Physicist/Engineer, The English Electric Co. Ltd., attached to Reactor Division, Atomic Energy Research Establishment, Harwell, Berks.

Greener, John Rochester, B.Sc., Lecturer, Rutherford College of Technology, Newcastle-on-Tyne.

*Griffiths, Neill, B.Sc., Scientific Officer, Armament Research and Development Establishment, Fort Halstead, Kent.

Hewitt, Sydney Joseph, B.Sc., Ph.D., Research Engineer, Electric and Musical Industries Ltd., Hayes, Middlesex.

Jain, Suresh Chand, B.Sc., Ph.D., I.C.I. Fellow, University of Leeds.

Jakes, Charles Joseph, B.Sc., Assistant Lecturer, South-East Essex Technical College, Dagenham.

*Levine, Martin, M.Sc., Iltrasonoscope Co. (London) Ltd., London.

*McAllan, John Vian, B.Sc., Research Officer, National Standards Laboratory, Sydney.

McKeown, Patrick Joseph Augustine, M.Sc., Ph.D., Assistant Lecturer, Imperial College, London.

Marsden, Philip, B.Sc., Head of Physics Department, Cotham Grammar School, Bristol.

Midgley, John Winwood, M.Sc., Section Head, The English Electric Co. Ltd., Whetstone, Leicester.

Monteith, John Lennox, B.Sc., Ph.D., Research Physicist, Rothamsted Experimental Station, Herts.

*Morgan, Roderic Henry Charles, B.Sc., Research Engineer, Mullard Radio Valve Co. Ltd., Salfords, Surrey.

*Newell, Frederic William, B.Sc., Senior Physicist, Triplex Fundamental Research Laboratories, Balsall Common, Warwicks.

*Pinnock, Peter Rowley, B.Sc., Ph.D., Physicist, Nuclear Power Plant Co. Ltd., Knutsford, Cheshire.

*Rossman, Michael George, M.Sc., Ph.D., Research Fellow, University of Minnesota, U.S.A.

Slaughter, Raymond Jeffrey, B.Sc., Section Leader, The Telegraph Construction Co. Ltd., London.

*Smith, Hugh Archer Finn, M.Sc., Lecturer, County Technical College, Guildford, Surrey.

Thomason, James Gordon, B.Sc., Senior Scientific Officer, Royal Radar Establishment, Malvern, Worcs.

*Tootill, Eric Gordon, B.Sc., Lecturer, County Technical College, Stafford.

*Tweedy, John Noel, B.Sc., Assistant Manager, U.K. Atomic Energy Authority, Calder Hall, Cumberland.

Williams, Harry Stedwill, B.Sc., Principal Physicist, Royal Free Hospital, London.

*Willis, Vincent, B.Sc., Technical Officer, Nobel Division, Imperial Chemical Industries Ltd., Stevenston, Ayrshire.

GRADUATES

Albutt, Robert Clifford, B.Sc., Senior Assistant Physicist, West Midlands Gas Board, Birmingham.

Andrews, Gordon James, B.Sc., Science Master, Public Secondary School, Plymouth.

Appleby, Douglas Edward Marrison, B.Sc., Management Accountant, The Distillers Co. Ltd., London.

Bennett, Joan Margaret, B.Sc., Student, Department of Education, University of Bristol.

Bevan, Norman Ernest, B.Sc., Technical Officer, Medical Research Council.

*Birch, John, B.Sc., Engineer, Associated Electrical Industries Ltd. — John Thompson Nuclear Energy Co. Ltd., Knutsford, Cheshire.

Boardman, Roger Phillips, B.Sc., Physicist, Ericsson Telephones Ltd., Beeston, Nottingham.

Bowling, Alan, B.Sc., Apprentice Supervisor, Metropolitan-Vickers Electrical Co. Ltd., Manchester.

Brooke, Raymond, B.Sc., Engineer, British Telecommunications Research Association, Taplow, Berks.

*Cartwright, Bruce Bingham, B.Sc., Graduate Apprentice, British Insulated Callender's Cables Ltd., Prescot, Lancs.

*Constable, Keith Julian Bernard, B.Sc., Postgraduate Student, University of Birmingham.

Delf, Brian William, B.Sc., Research Assistant, University College of South Wales, Cardiff.

*Dickinson, Philip John, B.Sc., Postgraduate Trainee, Hawker Aircraft Ltd., Kingston-on-Thames, Surrey.

Dickinson, Robert William, B.Sc., Research Officer, Simon-Carves Ltd., Cheadle Heath, Stockport.

Giorgi, Tiziano Anselmo Giuseppe, B.Sc., Research Assistant, Northampton College of Advanced Technology, London.

Hadley, Dennis William, B.Sc., Research Fellow, University of Liverpool.

Harburn, George, B.Sc., Research Student, College of Science and Technology, Manchester.

Harding, Anthony Philip, B.Sc., Development Engineer, Metropolitan-Vickers Electrical Co., Ltd., Manchester.

Hill, Derek Raymond, Assistant Engineer, Standard Telecommunication Laboratories Ltd., Enfield, Middlesex.

*Holmes, Ernest Leonard, B.Sc., Research Student, University of Toronto.

Ingham, Peter, B.Sc., Student, Department of Education, University of Leeds.

*Jones, Clifford Kenneth, B.Sc., Research Student, Imperial College, London.

Jones, Donald William, B.Sc., Research Student, University of Birmingham.

Jones, John Frederick, B.Sc., Physicist, Dunlop Rubber Co. Ltd., Birmingham.

Kennedy, Donald John, B.Sc., Engineer, Associated Electrical Industries Ltd. — John Thompson Nuclear Energy Co. Ltd., Knutsford, Cheshire.

Lancaster, Gordon, B.Sc., Research Associate, King's College, Newcastle-upon-Tyne.

Lee, Michael Adrian, B.Sc., Assistant Experimental Officer, Post Office Research Station, London.

Likely, Francis Patrick, B.Sc., Part-time Teacher, College of Technology, Portsmouth.

Long, John Wallace, B.Sc., A.R.C.S., National Service, attached to Research Department, Atomic Weapons Research Establishment, Aldermaston, Berks.

Long, Victor John, B.Sc., Research Physicist, Dunlop Rubber Co. Ltd., Birmingham.

*Macleod, James Edward Strang, A.R.T.C., Research Student, University of Glasgow.

Maddison, Ronald Charles, B.Sc., Research Student, University College of North Staffordshire.

Matthews, Graham George, B.Sc., Research Physicist, C. A. Parsons & Co. Ltd., Newcastle-on-Tyne.

Oliver, Colin Charles, B.Sc., Research Engineer, Electric and Musical Industries Ltd., Hayes, Middlesex.

*Packwood, Albert, Glamorgan Technical College, Treforest.

Rands, John David, B.Sc., Scientific Staff, The General Electric Co. Ltd., Stanmore, Middlesex.

Renny, Henry Bruce, Assistant Experimental Officer, Ministry of Supply, Fort Halstead, Kent.

Rogers, B. J., B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Harwell, Berks.

Rooke, Alan David, B.A., Research Physicist, Electric and Musical Industries Ltd., Hayes, Middlesex.

Rout, Vivian Mary, M.Sc., Research Physicist, Associated Electrical Industries Research Laboratory, Aldermaston, Berks.

Sanders, Arthur Joseph, B.Sc., Technical Officer, British Nylon Spinners, Ltd., Pontypool, Mon.

Smithers, Brian William, B.Sc., Research Assistant, Northern Polytechnic, London.

Spring, Neil Frederick, B.Sc., A.R.C.S., Scientific Officer, British Insulated Callender's Cables Ltd., London.

Springate, John, B.Sc., Lecturer, Paisley Technical College, Renfrewshire.

Stowell, Michael James, B.Sc., Research Student, H. H. Wills Physical Laboratory, University of Bristol.

Wilkins, Kenneth, B.Sc., Technical Staff, Sir W. G. Armstrong Whitworth Aircraft Ltd., Aberporth.

Williamson, Edward, B.Sc., Assistant, Taunton Technical College, Somerset.

Young, Kenneth Moir, M.A., Trainee, Metropolitan-Vickers Electrical Co. Ltd., Manchester.

Sixty-two students and two subscribers were also elected.

The Institute's Journals

PRINCIPAL CONTENTS OF THE JANUARY, 1958, ISSUES

Journal of Scientific Instruments: Volume 35, No. 1

SPECIAL ARTICLE

Silicones and their applications. By J. Ames.

The characteristics of the polysiloxane chain are described, and their effects on the properties of silicones are discussed. Silicones possess excellent thermal stability over a temperature range of more than 300°C, low surface tension, good electrical properties and a high degree of water-repellency, and are effective as release agents. The mechanical properties of the condensed polysiloxanes are poorer than those of most organic polymers at moderate temperatures, but are markedly superior at extremes of temperature. Silicones are available in the form of fluids, rubbers and resins ; the manufacture and properties of each are described, and their special applications are discussed.

ORIGINAL CONTRIBUTIONS

A rhodium-plated kata thermometer for measuring true air velocity. By W. Koch and D. Kaplan.

Rhodium-plated kata thermometers were developed, as rhodium is a more stable coating then silver. The rhodium-plated kata thermometers were tested in non-turbulent air streams at the National Physical Laboratory, Teddington. Formulae for estimating true air velocities from cooling rates of the kata thermometers are given. Accompanying graphs facilitate the calculation of velocities. Cooling of the instruments is not directly related to the square root of the air speed at low velocities. From zero speed (still air) up to a velocity of 0·5 m/s, plotting of cooling against velocity results in a parabola, and from 0·5–1·3 m/s in a straight line.

A 20-ft. Ebert grating spectrograph. By G. W. King.

The design and construction of a new high-resolution spectrograph for the visible and ultra-violet regions of the spectrum are described. The optical system is that due to Ebert, in which a plane diffraction grating is used in conjunction with a spherical mirror as collimator and camera. This system has several advantages over conventional concave grating mountings ; a stigmatic image is formed and wavelength change is accomplished simply by rotation of the grating. The instrument described can also be used as a spectrophotometer, and can be adapted for use in the vacuum ultra-violet.

Correction due to aperture in transmission interference microscopes. By E. Ingelstam and L. P. Johansson.

The fringe spacing in transmission interference microscopes is shown to require a correction due to the oblique rays, with respect to the ordinary value valid for perpendicular rays. The spacing, and accordingly the measured path differences, $t(n_E - n_O)$, are smaller

than the normal values (opposite to the case of reflexion microscopes). Calculations are made for different values of condenser N.A. and varied parameters, showing corrections up to -15%. The fringe intensities also decrease with the order of interference when it is low. Experiments confirm these findings. The effect is discussed in relation to some general ideas of (x, y)-fidelity and (z)-fidelity as obtained in a limited optical information channel.

A total-absorption Čerenkov counter for photons of about 100 MeV energy. By J. Moffatt and M. W. Stringfellow.

The counter uses a cylindrical crystal of thallous chloride 12 cm long and 9·3 cm in diameter viewed by a photomultiplier tube, and is capable of giving pulses of up to 3 V in height without serious departure from linearity. The pulse height resolution for 78 MeV photons is 34%, and both the mean pulse height and resolution remain constant to within 5% over an entrance aperture 5 cm in diameter. The performance of the counter is discussed in some detail, and it appears that the resolution is limited principally by strong absorption of ultra-violet light in the crystal.

A d.c. and square wave a.c. resistance and voltage comparator. By T. M. Dauphinee and H. Preston-Thomas.

A compact resistance and voltage comparator employing an isolating potential circuit with mechanical choppers has proved to be a versatile and accurate laboratory tool. Voltages can be compared with an accuracy of 10^{-8} V and resistors with an accuracy of 2 parts in 10^6 (d.c. operation) or 2 parts in 10^5 with automatic cancellation of thermal e.m.f. (square wave operation). When a d.c. amplifier and recorder are used, voltage and resistance differences may be recorded with an accuracy of about 2 parts in 10^3.

A gas target and nuclear plate camera. By D. L. Booth, R. S. Hill, F. V. Price, D. Roaf, and G. L. Salmon.

A windowless gas target capable of maintaining a pressure of up to 2 mm of mercury has been constructed to determine the differential cross-section of charged particle reactions. Targets of this type have been used to examine (d, p) and (d, α) reactions in the range 15 keV to 1 MeV.

Automatic temperature programming and recording for a platinum-rhodium furnace. By J. M. Cutter and R. Derry.

The resistance of the platinum-rhodium alloy varies with temperature so much that a fully automatic programming controller must incorporate a device for adjusting the voltage applied to the winding as the furnace temperature changes. The way in which this was achieved, by means of a servomechanism, is described.

An apparatus for the determination of dynamic elastic moduli at low strains. By E. V. Vernon, A.Inst.P.

An electronic apparatus is described for the determination by a resonance method of Young's modulus and the modulus of rigidity of materials in the form of cylindrical rods. Results can be obtained at strains as low as 10^{-9}. The method of calculation of the moduli from the observed resonant frequencies is given.

A note on progressive codes for positive and negative indication. By W. T. Bane.

The note describes a simple modification to progressive codes used in coded-plate digitizers so that a signed readout can be obtained. Little increase in the complexity of the decoding equipment is necessary and neither the accuracy of readout nor the maximum tolerance of the digitizer to mechanical imperfections is impaired.

British Journal of Applied Physics: Volume 9, No. 1

CONFERENCE REPORT

Summarized proceedings of a conference on biological structures and computational methods—London, November, 1956.

The annual Autumn Conference of the X-ray Analysis Group of the Institute of Physics was held in London on 16 and 17 November, 1956. The three sessions dealt with crystallographic computing for large molecules ; globular and fibrous proteins ; and viruses and nucleic acids.

ORIGINAL CONTRIBUTIONS

Measurement of elasticity and anelasticity of small disks by an inductor method. By G. Bradfield and F. A. Levi.

An instrument is described operating on the inductor principle to set a small disk into radial vibration so that one of its elastic constants can be determined from its frequencies of resonance. The method of testing also permits the internal friction to be measured as the ratio Q_m of the real to the imaginary component of the elastic compliance. The accuracy of determination of the resonance frequency is to better than 1 part in 50,000 and the determination of the internal friction ratio to better than 1 part in 50 in a typical case when, for example, the above ratio Q_m is about 3,000. The elastic constant directly derived is the "sheet" modulus $E/(1-\sigma^2)$ where σ is Poisson's ratio and E is Young's modulus.

The use of polytetrafluoroethylene as a lubricant. By E. Kay, A.Inst.P., and E. D. Tingle.

The use of the polymer polytetrafluoroethylene (P.T.F.E.) in bulk form as a bearing is limited by its low strength and poor thermal conductivity. Experiments are described in which these difficulties are overcome by the deposition of thin films of P.T.F.E. on to metal subtrates.

Frictional tests under a variety of conditions show that tenacious films of low frictional coefficient and high

load-carrying capacity can be prepared. These properties are considerably enhanced by using a surface phosphating treatment prior to application of the P.T.F.E.

A technique for obtaining thin foils of aluminium alloys for transmission electron metallography. By R. B. Nicholson, G. Thomas and J. Nutting.

The structural changes produced by ageing aluminium-copper and aluminium-magnesium-zinc-copper alloys have been investigated by examining foils of these alloys in the electron microscope. The foils have been obtained by mechanical reduction in thickness followed by controlled electro-polishing and chemical dissolution of the remaining oxide film.

An overall test of equations of state of fluids. By N. Davy and Barbara M. Bell, Grad. Inst.P.

An equation of state of a fluid can usually be expressed in the form $f_1(V, T) = P$. When the reduced form of the equation exists, it may be expressed as $f_2(v, t) = p$, where p, v, and t are the reduced values of P, V, and T. Since the critical volume cannot be measured with precision, the recent fashion is to use, instead of v, the accurately obtainable pseudo-reduced volume φ, leading to a reduced equation $f_3(\varphi, t) = p$. It is now suggested that a calculation and plot of the quantity $Y = 100[f_3(\varphi, t)/p - 1]$ against $X = p$ (t constant) or $X = t$ (p constant), using experimental values of p, φ, and t for some real fluid, will reveal in a quantitative manner the discrepancy between the experimental behaviour of that fluid, and of a fluid obeying the particular equation of state under consideration. A set of graphs at various constant temperatures or pressures may be drawn.

The electric strength and molecular structure of liquids. By T. J. Lewis.

Further measurements of the electric strength of liquids are used to support the theory of a breakdown criterion, suggested in an earlier paper, in which conduction electrons in the liquid excite molecular vibrations associated with individual groups within the molecules. It has been demonstrated that collision cross-sections could be assigned to these groups and the breakdown strength derived. This criterion is used to relate the breakdown strengths of a series of alkyl benzenes recently measured by Sharbaugh, Crowe and Cox and a cross-section for the benzene ring is determined. The additive effect of the various group cross-sections is found as before, but it is necessary to consider dipole effects as well as liquid structure in order to explain the increased cross-section values for the alkyl groups. The general correctness of the concept is further demonstrated by measurements of the strength of a series of dimethyl siloxanes. It is assumed that cross-sections are to be associated with the oxygen sites and also with the methyl groups. The value of the methyl cross-section determined in this case is identical with that found from the previous measurements on the alkanes. Lastly, the presence of a puckered ring structure as well as steric hindrance is suggested as the cause of the strength of cyclohexane calculated from alkane measurements being different from the measured value.

Photoelastic investigation of stresses in composite models with notches and holes. By Heihachi Shimada.

The object of the work described was to obtain information about the stresses in stiffened plastic bars. Tests were carried out under tension on a composite bar with a circular hole, and under bending, on a composite bar with a semicircular notch. The bars were of epoxy resin stiffened with duralumin strips. Graphs were obtained from which the stress-concentration factors of the stiffened models may be deduced from those in similar unstiffened models.

The effect of specimen diameter on the straining of a cylindrical load-cell. By J. F. W. Bishop and M. T. Watkins, A.Inst.P.

Theoretical and experimental results on the surface axial distortion of a cylindrical load-cell loaded by circular punches of differing diameters are given. It is concluded that a height to diameter ratio of about 7 : 4 is required to eliminate end effects and the effect of specimen diameter on the loads recorded near its centre.

Determination of density of liquids under elevated gas pressure. By K. Goldman.

A new method of density measurement using an open-end hydrometer has been developed for liquids under elevated gas pressure. It has been successfully employed for determining densities of high vacuum oil (Apeizon A), saturated with nitrogen, at 25°C in the pressure range 1–300 atm. The estimated accuracy of determination was better than 1 in 1000.

THE GAS COUNCIL MIDLANDS RESEARCH STATION

Applications are invited from suitably qualified Chemists, Physicists, Chemical Engineers and Fuel Technologists for appointments in this newly established research station, which is concerned with novel methods of gas manufacture and with improving the use of gas, especially in industry.

Candidates should hold, at least, a second class honours degree of a British University, or an equivalent qualification and be free of National Service liabilities. Postgraduate research experience is an advantage. Men and women who after experience show the qualities of effective leadership of investigations will be paid salaries commensurate with these attributes. The station is in Solihull in Warwickshire and is within easy reach of Birmingham.

Applications in writing, detailing education, qualifications and experience, should be sent to the Industrial Relations Officer, West Midlands Gas Board, 6 Augustus Road, Edgbaston, Birmingham, 15.

J. Swan,
Secretary to the Board.

McMASTER UNIVERSITY

Graduate Scholarships in Physics

Applications are invited for graduate scholarships in the Department of Physics, McMaster University, from high-ranking students qualified to register in courses leading to the M.Sc. and Ph.D. degrees. These scholarships may be supplemented by departmental assistantships, requiring 10-12 hours per week service during the seven-month academic year, to provide a yearly income of $1,700 to $2,000. Research is in progress in the following fields : Theory of molecular forces (F. R. Britton) ; Atomic mass determinations (H. E. Duckworth) ; Beta- and gamma-spectroscopy (M. W. Johns) ; Molecular spectroscopy (G. W. King) ; Metal physics (J. S. Kirkaldy) ; Microwave optics (A. B. McLay) ; Solid state physics (H. E. Petch) ; Theoretical nuclear physics (M. A. Preston) ; Atomic beam physics (R. G. Summers-Gill) ; Fission yields and isotopes abundance (H. G. Thode) ; Mass spectrometry (R. H. Tomlinson) ; Quantum theory of matter (P. R. Zilsel).

Graduate calendars and application forms for graduate study may be obtained from the Faculty of Graduate studies. Further information concerning the Department of Physics and applications for departmental scholarships may be obtained from Professor H. E. Duckworth, Department of Physics, Hamilton College, McMaster University, Hamilton, Ontario, Canada.

RESEARCH PHYSICISTS or CHEMISTS required by Consultants for interesting experimental projects on electrical materials and components. Starting (Senior) £1,000 to £1,750 p.a. according to knowledge and experience, (Junior) £700 to £1,000. G. V. Planer Ltd., Windmill Road, Sunbury, Middlesex.

PHYSICIST or X-RAY CRYSTALLOGRAPHER with post-graduate research experience required for fundamental research group in North London laboratories. Some knowledge of metallurgy desirable. Salary according to age and experience. Apply in writing to Research Manager, Murex Welding Processes Ltd., Waltham Cross, Herts.

CAREERS FOR ENGINEERS AND SCIENTISTS
in the
GENERAL ELECTRIC COMPANY LTD.

The expanding activities of the G.E.C. are backed by a research and development organization which is probably unequalled in the industrial field. At the Company's laboratories and works a wide range of research activity, including fundamental as well as development work, is taking place in many branches of physics, electronics and electrical, mechanical and nuclear engineering.

The Company offers progressive and attractive careers to scientists and technologists in a wide variety of interesting fields. Graduate training courses are also available.

PROFESSIONAL TRAINING SCHEMES FOR SCHOOL LEAVERS

The G.E.C. offers a variety of training schemes for boys who wish to make industrial careers in such new and developing technological activities as :

Nuclear Engineering · Electronics
Telecommunications
Traction · Applied Physics · Power Plant
Electrical Engineering
Steam Turbines · Guided Missiles
Heavy and Light Mechanical Engineering

These courses lead to appointments in
Design · Development · Research
Production · Commercial Engineering
and also responsible posts in **Management**

G.E.C.

For further information write to :
THE CONTROLLER, EDUCATION AND PERSONNEL SERVICES (IPB)
THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, LONDON, W.C.2.

A World-wide Organization Employing 70,000 *People*

GRIFFIN & GEORGE LTD.

Ealing Road, Alperton, Wembley, Middlesex

are expanding their Research and Development Division to meet the growing demands from Industry and Education for scientific and laboratory apparatus of all kinds—mechanical, electrical, optical, glassblown. The scientific instrument industry offers opportunities for an interesting and progressive career. Griffin & George need :—

Physicists — good degree with interest in apparatus and practical bent. One as personal assistant to Technical Director.

Senior Designer — B.Sc.(Eng.) or H.N.C.

Five day week ; pension scheme ; canteen

Please write details of career and salary required to Technical Director

AUSTRALIA — UNIVERSITY OF NEW ENGLAND

Applications are invited for the position of Lecturer in Physics.

Salary according to qualifications and experience, within the range £A1,200 × £A80 – £A1,750, and in addition a cost of living allowance, at present amounting to £A70 (males) or £A53 (females) is payable.

The salary is subject to deductions under the State Superannuation Act. The successful applicant will be expected to take up duties as soon as can be arranged after the date of appointment.

Finance is available for home purchase under the Staff Housing Scheme.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

The closing date for the receipt of applications in Australia and London is January 31, 1958.

A qualified PHYSICIST or PHYSICAL CHEMIST is required by the United Insulator Co. Ltd., for a post in its Technical Department. The Company manufacture dielectric and piezo-electric ceramic materials, and the work would include both development and process control aspects. Experience of ceramic techniques would be helpful, but is not essential. Pension scheme, 5-day week, attractive starting salary according to qualifications and experience. Reply to the Technical Manager, United Insulator Co. Ltd., Oakcroft Road, Chessington, Surrey.

Physics in Industry Series

PHYSICS OF FIBRES

AN INTRODUCTORY SURVEY

BY

H. J. Woods, M.A., F.Inst.P.

Lecturer in Textile Physics, University of Leeds

The emphasis throughout this book is on the natural rather than the man-made fibres, but anyone who knows something about cellulose and keratin will find little difficulty with other fibres. The author's object has been to provide an introduction to the subject for scientists commencing research and development work in this field by indicating the lines along which the physical approach to the study of the structure and properties of fibres has proceeded.

He has also had in mind the scientists whose interests are in other fields, but who may wish to learn something about the ways in which physics has helped in advancing our knowledge of fibres.

A bibliography and fairly full list of references have been provided for those who wish to pursue the subject further.

price 30s. including postage, to members of the Institute 25s.

BRITISH PETROLEUM COMPANY LIMITED have a vacancy in their Exploration Research Laboratories, Sunbury-on-Thames, for a physicist with an honours degree and several years' research experience, to work on some aspects of elastic wave propagation in the earth. Previous experience of one or more of the following types of work is desirable :—

(*a*) Instrumental development work on magnetic-tape recording and play-back systems, and particularly the application of correlation and other techniques to the output of multi-channel play-back equipment.

(*b*) Design and interpretation of small-scale seismic field programmes.

(*c*) Theoretical work on seismic propagation problems.

Salary according to age, qualifications and experience. Non-contributory Pension Fund. Assisted House Purchase Scheme. Removal expenses and settling-in allowance payable in certain cases. Luncheon Club. Write, giving full details, quoting H.3597B to the Manager, Recruitment Branch, The British Petroleum Company Limited, Britannic House, Finsbury Circus, London, E.C.2.

THE BRITISH BOOT, SHOE AND ALLIED TRADES RESEARCH ASSOCIATION have the following vacancies :—

Research on shoe manufacturing processes and materials. Two vacancies. Appointments will be at Scientific Officer or Senior Scientific Officer level with rapid advancement for men showing ability and drive. Qualifications :—honours degree in physics or engineering (or equivalent professional qualifications). Experience of applied research desirable, preferably in development or mechanical processing of materials. Physical testing of shoes and shoe materials. Vacancy for section leader. Interesting and varied laboratory work, also personal contacts with the Association's members. Qualifications :—degree in physics (or general science including physics) or H.N.C. in physics or other equivalent qualification. Laboratory experience, preferably in instrumentation or materials testing.

Fuller information (including salary ranges) gladly given to potential applicants, but please state experience, qualifications and age when writing. Knowledge of shoe industry is not expected. Posts carry superannuation (F.S.S.U. or Association's own scheme). Write to the Director, B.B.S.A.T.R.A., Satra House, Rockingham Road, Kettering, Northants.

"THE EDUCATION OF PHYSICISTS IN UNIVERSITIES AND COLLEGES OF TECHNOLOGY"

Being the proceedings of a Conference on

"DEGREE AND DIPLOMA COURSES IN APPLIED PHYSICS"

organized jointly by the Institute of Physics and the London and Home Counties Regional Advisory Council for Higher Technological Education.

The booklet contains papers by :—

SIR JOHN COCKCROFT, PROF. P. M. S. BLACKETT, MR. R. E. BURNETT, PROF. H. LIPSON, DR. J. THOMSON, PROF. M. R. GAVIN, DR. J. TOPPING

PUBLISHED BY THE INSTITUTE OF PHYSICS *PRICE SIX SHILLINGS*

The Institute of Physics

MONOGRAPHS FOR STUDENTS SERIES

Humidity

H. L. PENMAN, PH.D., F.INST.P., *Head of Physics Department, Rothamsted Experimental Station*

After summarizing the fundamentals of the subject many methods of measuring and controlling humidity are described. A good grasp of some parts of this monograph and a general understanding of all of it should be a prerequisite for those concerned with the problems of atmospheric and soil humidity.

PRICE : Non-Members 5s. Members (for personal use) 3s. 6d.

Errors of observation and their treatment

J. TOPPING, PH.D., F.INST.P., *Principal, Acton Technical College*

Every teacher of experimental physics knows how "results" given to three or four decimal places are often in error in the first place; students suffer from "delusions of accuracy." At a higher level too, more experienced workers sometimes claim a degree of accuracy which cannot be justified. A consideration of the topics discussed in this monograph may stimulate in students an attitude to experimental results at once more modest and more profound.

PRICE : Non-Members 5s. Members (for personal use) 3s. 6d.

The Institute of Physics, 47 Belgrave Square, London, S.W.1

SECRETARY wanted by Head of large University Department. Some acquaintance with scientific matter an advantage. Salary in the range of £430–500 (Grade I), according to qualifications and experience. Applications to Professor E. G. Cox, F.Inst.P., F.R.S., Department of Inorganic and Structural Chemistry, The University, Leeds, 2.

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(Faculty of Technology in the University of Manchester)

Appointment of
Demonstrator in Physics

The Governing Body invites applications for a Demonstratorship in Physics. The Demonstrator will be required to assist the teaching staff in practical classes and in tutorials. He will also be allowed ample time for research and will be expected to become a candidate for a higher degree.

Salary : £575 × £25 – £600. Superannuation under F.S.S.U. Family allowances.

Forms of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester 1, to whom they should be returned by January 31, 1958.

B. V. Bowden,
Principal of the College.

COURSES

MIDDLESEX COUNTY COUNCIL
EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY
WOODLANDS AVENUE, ACTON, W.3.

The following advanced course in Applied Physics suitable for graduates or holders of Higher National Certificate has been arranged :

ULTRASONICS

Six week course on Wednesday evenings from 7 to 9 p.m. commencing February 12, 1958.
Further particulars may be obtained from the Principal.

C. E. Gurr, M.Sc., Ph.D.
Secretary to the Education Committee.

Chartered Patent Agents

W. H. BECK, GREENER & CO.

7 Stone Buildings,
Lincoln's Inn,
Chancery 2535 London, W.C.2

PRINTED BY F. J. MILNER AND SONS LIMITED, COMMERCE ROAD, BRENTFORD, MIDDX.

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

UNIVERSITY OF LEEDS

HOULDSWORTH SCHOOL OF APPLIED SCIENCE

Two temporary research assistants are required in the Ceramics Group of the Houldsworth School of Applied Science for a study of permeability of ceramics to gases at high temperature. The work will be mainly physics and physical chemistry and may lead to a higher degree. Salary within the range £400–£750 according to age, qualifications and experience. Applications should reach Professor A. L. Roberts, The University, Leeds, 2, not later than February 28.

WOOL INDUSTRIES RESEARCH ASSOCIATION

PHYSICIST, male, 1st or 2nd class honours or A.Inst.P. for weaving research. Work involves application of mathematics and modern experimental methods to complex mechanical systems. Starting salary on Scientific Officer scale up to £930 p.a. with F.S.S.U. benefits depending on age and qualifications. Apply to the Association, Torridon, Headingly, Leeds, 6.

COMMONWEALTH OF AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF INDUSTRIAL CHEMISTRY

Appointment No. 590/658 of Research Spectroscopists

The organization's Division of Industrial Chemistry is at present seeking to appoint two Research Spectroscopists. The Division is located in modern and well equipped laboratories at Fisherman's Bend, Melbourne. The Spectroscopy group is part of the Chemical Physics Section which includes thirty Research Officers and twenty-two Technical and Workshops staff.

The appointees will be required to work on the following Research topics :

(1) Development of the field of atomic absorption spectroscopy and its application to theoretical and applied problems, and

(2) Experimental and theoretical studies of electronic and vibrational spectra of co-ordination compounds in relation to structure.

Applicants should possess a University degree of Master of Science or Doctor of Philosophy in chemistry or physics, preferably with some research experience in the general field of spectroscopy. Successful applicants will be members of the Spectroscopy group, which has facilities for vacuum ultra-violet, visible and near ultra-violet, infra-red, Raman and echelle spectroscopy.

Dependent upon qualifications and experience, commencing salary will be determined within the salary ranges of Research Officer or Senior Research Officer £A1,313–£A1,938 p.a. or £A2,048–£A2,323 p.a. Salary for a female appointee will be £A167 less than the corresponding male rates quoted.

The appointment will be conditional upon a satisfactory medical examination and the appointee will be required to contribute to and eligible to receive benefits from either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Applications, quoting Appointment No. 590/658, and stating full name, place, date and year of birth, nationality, marital state, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by copies of not more than four testimonials and the names and addresses of three professional referees should reach the undersigned, from whom further particulars may be obtained, by February 28, 1958.

A. Shavitsky
Chief Scientific Liaison Officer
Australian Scientific Liaison Office,
Africa House,
Kingsway,
London, W.C.2.

MONSANTO CHEMICALS LTD.

require

YOUNG GRADUATES

in applied physics, physics, or mechanical or chemical engineering to staff an expanding research programme in their Application Research Department. The field of work involved is the experimental study of the physical and mechanical properties of thermoplastic polymers and of the processes used in their fabrication, with a view to using the knowledge obtained in developing new uses for plastics.

Applicants should possess a good University degree or equivalent and a keen interest in properties of matter and rheology is very desirable.

The post is permanent and a good salary will be paid commensurate with qualifications and/or experience. A non-contributory pension scheme is now in operation.

Applications in writing, giving full details of age, training, qualifications and experience, should be sent to the Chief Personnal Officer, Monsanto Chemicals Ltd., 10-18 Victoria Street, London, S.W.1.

A GRADUATE PHYSICIST is required to conduct research into physical problems associated with the use of tungsten in lamps and valves. Previous experience in high vacuum techniques would be an advantage. Applicants are invited to write to the Director of Research, The British Thomson-Houston Co. Ltd., Rugby, stating age, qualifications, experience and quoting reference JSJ.

McMASTER UNIVERSITY

POST-DOCTORAL FELLOWSHIPS IN PHYSICS

Applications are invited for National Research Council and other Post-Doctoral Fellowships tenable in the Department of Physics, McMaster University. Successful applicants may choose to work full-time on their research or to supplement their research with a modest amount of lecturing. Inquiries and applications should be addressed to Professor H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

RICHARD THOMAS & BALDWINS LTD.
CENTRAL RESEARCH LABORATORIES, WHITCHURCH, AYLESBURY, BUCKS.

Applications are invited from Physicists looking for interesting and responsible posts, who would like to join a young and enthusiastic group engaged in the application of the newer physical techniques to both long and short term investigations in steelmaking, processing and instrumentation. Present activities, in which originality and inventiveness are encouraged, cover a wide field. Applicants should be of degree or equivalent standard, but previous experience is not essential. Commencing salaries will be in the range £650–£900 depending on age, qualifications and experience, with plenty of opportunity for advancement. Write, in confidence, giving full details of qualifications and experience to the Director of Research, Richard Thomas & Baldwins Ltd., Central Research Laboratories, Whitchurch, Aylesbury, Bucks.

RICHARD THOMAS & BALDWINS LTD.
CENTRAL RESEARCH LABORATORIES, WHITCHURCH, AYLESBURY, BUCKS.

There are vacancies in the Physics Department for Assistants. The duties are of a wide and useful nature covering many aspects of steelmaking and steel-processing research. Applicants should have reached a standard of education sufficient to allow them to pursue a course of part-time study leading to a professional qualification and should have the enthusiasm and keenness to achieve that end. Part-time further education is encouraged and excellent educational facilities are granted. Salaries are on a generous scale. Please forward applications, in confidence, to the Director of Research, Richard Thomas & Baldwins Ltd., Central Research Laboratories, Whitchurch, Aylesbury, Bucks.

UNIVERSITY OF GLASGOW
I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry, Engineering, Pharmacology, or Physics to which some appointments may be made during the current academic year. The appointments will date from October 1, 1958. The Fellows will hold the status of Lecturers in the University. The salary will depend upon qualifications and experience but will be within the range £700 to £1,000 per annum, rising to £1,100 per annum in exceptional cases, together with F.S.S.U. benefits and family allowances.

Applications (eight copies) with a list of publications and names of two referees, should be sent not later than February 28, 1958, to the undersigned, from whom further particulars may be obtained.

Robt. T. Hutcheson
Secretary of University Court.

BRITISH PETROLEUM CO. LTD., has vacancies for Geophysicists on its exploration staff. Candidates who should have some experience in the field and must have an honours degree in physics with subsidiary mathematics and/or Geology. Basic salary is commensurate with age and experience, commencing at £1,130 for young inexperienced graduates. Appropriate allowances are paid on foreign service. Generous pension scheme. Written applications, quoting reference F.533 should be addressed to Personnel Manager, British Petroleum Co. Ltd., Britannic House, Finsbury Circus, London, E.C.2.

IMPERIAL CHEMICAL INDUSTRIES LTD.
Billingham Division

Vacancies for

PHYSICISTS

Imperial Chemical Industries Ltd., Billingham Division, has several interesting vacancies for PHYSICISTS, to participate in research work in MECHANICAL ENGINEERING. In this department modern physical techniques are being applied to the investigation of vibration and noise control, friction and lubrication, stress analysis, and mechanics of engineering plant.

Candidates for these senior appointments should hold a good honours degree, and it is desirable that applicants should be able to show evidence of interest in one or other of these fields.

Imperial Chemical Industries Ltd. is noted for its progressive staff policy which offers :

Attractive salary and profit-sharing schemes

Pension fund, subsidized canteens, excellent social and game facilities.

Assistance with house purchase and removal expenses for married men.

Write, giving brief details of age, qualifications and experience, to the Staff Manager, Imperial Chemical Industries Ltd., Billingham Division, Billingham, Co. Durham, quoting reference W/1/5.

CAREERS FOR ENGINEERS AND SCIENTISTS
in the
GENERAL ELECTRIC COMPANY LTD.

The expanding activities of the G.E.C. are backed by a research and development organization which is probably unequalled in the industrial field. At the Company's laboratories and works a wide range of research activity, including fundamental as well as development work, is taking place in many branches of physics, electronics and electrical, mechanical and nuclear engineering.

The Company offers progressive and attractive careers to scientists and technologists in a wide variety of interesting fields. Graduate training courses are also available.

PROFESSIONAL TRAINING SCHEMES FOR SCHOOL LEAVERS

The G.E.C. offers a variety of training schemes for boys who wish to make industrial careers in such new and developing technological activities as :

Nuclear Engineering · Electronics
Telecommunications

Traction · Applied Physics · Power Plant
Electrical Engineering

Steam Turbines · Guided Missiles

Heavy and Light Mechanical Engineering

These courses lead to appointments in
Design · Development · Research
Production · Commercial Engineering
and also responsible posts in **Management**

G.E.C.

For further information write to :
THE CONTROLLER, EDUCATION AND PERSONNEL SERVICES (IPB)
THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, LONDON, W.C.2.

A World-wide Organization Employing 70,000 People

McMASTER UNIVERSITY
GRADUATE SCHOLARSHIPS IN PHYSICS

Applications are invited for graduate scholarships in the Department of Physics, McMaster University, from high-ranking students qualified to register in courses leading to the M.Sc. and Ph.D. degrees. These scholarships may be supplemented by departmental assistantships, requiring 10-12 hours per week service during the seven-month academic year, to provide a yearly income of $1,700 to $2,000. Research is in progress in the following fields : Theory of molecular forces (F. R. Britton) ; Atomic mass determinations (H. E. Duckworth) ; Beta- and gamma-spectroscopy (M. W. Johns) ; Molecular spectroscopy (G. W. King) ; Metal physics (J. S. Kirkaldy) ; Microwave optics (A. B. McLay) ; Solid state physics (H. E. Petch) ; Theoretical nuclear physics (M. A. Preston) ; Atomic beam physics (R. G. Summers-Gill) ; Fission yields and isotopes abundance (H. G. Thode) ; Mass spectrometry (R. H. Tomlinson) ; Quantum theory of matter (P. R. Zilsel).

Graduate calendars and application forms for graduate study may be obtained from the Faculty of Graduate studies. Further information concerning the Department of Physics and applications for departmental scholarships may be obtained from Professor H. E. Duckworth, Department of Physics, Hamilton College, McMaster University, Hamilton, Ontario, Canada.

THE CONTROLLER OF RESEARCH of a Company of international reputation manufacturing a wide range of Scientific Instruments requires a Personal Assistant.

This is a post which will give valuable administrative experience and offers the prospect of a progressive career with an expanding Company. The essential requirements are an honours degree in physics, a lively and enquiring mind and the ability to work harmoniously with colleagues. Suitably qualified young men, who need not have had previous experience, are invited to write giving full details of their careers to date to the Chief Personnel Manager, Hilger & Watts Ltd., 98 St. Pancras Way, Camden Road, London, N.W.1.

DAVID BROWN INDUSTRIES LTD., Foundries Division, Penistone, Sheffield, have a vacancy for a qualified Radiologist to control a laboratory dealing with steel and non-ferrous castings, including products to A.I.D. requirements. Good salary for experienced man. Superannuation facilities available. Assistance may be given with housing. Apply giving full details to Personnel Superintendent.

UNIVERSITY OF KHARTOUM

Applications are invited for the

CHAIR OF PHYSICS

Salary £S2,760 p.a. Cost of living allowance approximately £S100 p.a. Outfit allowanee £S50. Family allowances : wife—£S60 p.a., 1st child—£S90 p.a., 2nd and 3rd child—£S30 p.a. each. (£S1 = £1 0s. 6d. sterling.) Passages for appointee and family on appointment, termination and annual leave. Superannuation scheme. Appointment on contract for five years.

Detailed applications (eight copies) naming three referees by April 15, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

AUSTRALIA—UNIVERSITY OF MELBOURNE

Applications are invited for two positions of Senior Lecturer or Lecturer in Physics.
The salary ranges are :

Senior Lecturer : £A2,100–£A2,500 per annum
Lecturer : £A1,450–£A2,100 per annum.

Status and commencing salary will be fixed according to qualifications and experience.
Superannuation similar to F.S.S.U. in Great Britain will be provided. Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications in Australia and London is February 28, 1958.

PHYSICIST

IRAQ PETROLEUM CO. LTD. requires a Physicist for work in its Reservoir Engineering Laboratory in London on the analysis of reservoir performance with the aid of electric analogue computors. Applicants should have a good honours degree and some experience of electronics.
The selected candidates will be required to spend a short initial period in the Middle East to acquaint himself with the background of the work he will be doing in London. Age range 25-30. Salary will be assessed according to age and experience but will not be less than £800 per annum at 25. There is a pension scheme and a luncheon club in the building. Write in full to Staff Manager, Iraq Petroleum Co. Ltd., 214 Oxford Street, London, W.1.

SMITHS AIRCRAFT INSTRUMENTS LTD., require Physicist or Engineer to develop insulating systems for use in light electrical engineering applications. Candidates should be of degree standard and preferably acquainted with modern methods of impregnation and encapsulation. Salary commensurate with qualifications and experience. Apply, Personnel Manager, Bishops Cleeve, Nr. Cheltenham, Glos.

STATISTICIAN

An all-round able young Statistician required by expanding progressive clothing manufacturers. He will work in conjunction with the Directors in the application of statistical procedures to factory production, raw material purchasing, and sales forecasting. This is a permanent position leading to executive status. Commencing salary £750–£1,000 p.a. Mark Lewis (Marchette) Ltd., 133 Rye Lane, Peckham, London, S.E.15.

UNIVERSITY OF OXFORD

GEORGE KELLY READERSHIP IN METALLURGY

Notice is given that the above readership is vacant. The salary is on the scale £1,700 to £2,150 plus children's allowances. The electors intend to limit their consideration to metal physicists. Applications in eight copies and naming three referees but without testimonials should reach the Registrar, University Registry, Oxford (from whom further particulars can be obtained) by March 20, 1958.

Insurances for Physicists

☐ **RETIREMENT PENSIONS** with full Tax Relief (1956 Finance Act)

☐ **ENDOWMENT ASSURANCE.** An adaptable policy suitable for Investment, House Purchase or a Tax-free capital sum on retirement.

☐ **NON-CANCELLABLE SICKNESS AND ACCIDENT INSURANCE,** providing an income during disablement up to age 65.

☐ **MOTOR INSURANCE.** Special Scheme with immediate 33⅓% no claims bonus.

Name..... Date of Birth.....
(BLOCK LETTERS PLEASE)

Address .....

These policies are of particular interest to physicists.

For further details please complete this form and send to :

WALTER HERRIOT & CO. LTD.
Incorporated Insurance Brokers
Broad Street House, 54 Old Broad Street, London, E.C.2
(Telephone : LONdon Wall 7007/8)